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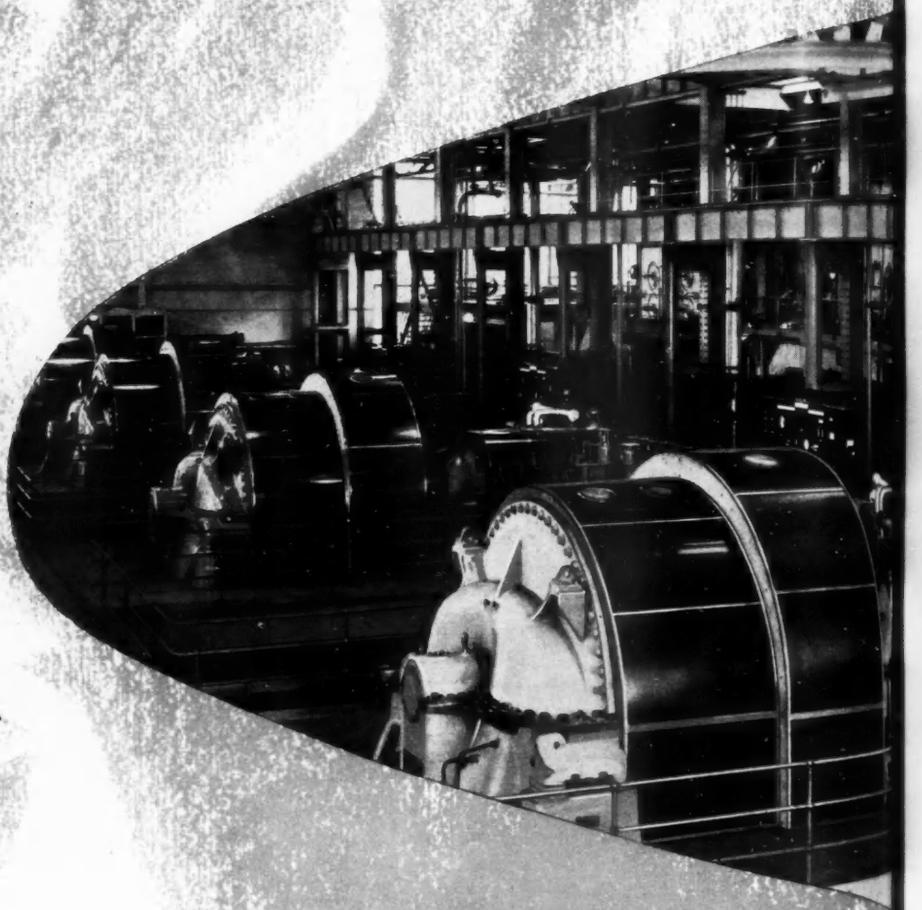
WHIRLWIND FROM THE POWER HOUSE



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ENGINEERING

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The Appointed Man

THIS is a time of year when many men are settling down to a new appointment. For them, and for those around them, the adjustments are seldom easy to make without offending or upsetting somebody. These disturbances of personal relationships strike at the heart of the individual's secret hopes and fears, and if the complications are not resolved they may remain only partly suppressed for years hence.

It was an American who remarked recently, and with a wistfulness which showed that he had suffered himself, that most of the important decisions affecting a man's career were made by others. But he added, with characteristic American perspicacity, that once in a while the decision could be reached by the man himself; the trick was to know when. That other people decide your future is a fact which you have to accept for most of your life. It would be a crazy world in which men promoted and posted themselves. (Not that everyone would want to be the managing director; indeed, the M.D. might surprise everyone by reducing himself to the ranks.) But it is fortunate that things are arranged as they are, because when an order for promotion or posting comes from above, it leaves the man in some degree independent of the decision. He has no need to excuse himself to those who are jealous, and they can, if they wish, put the blame on the broad shoulders of those who are paid to shoulder responsibility. A man who pushes himself too eagerly and too obviously, foregoes the advantages of this delicate regulating mechanism. He may even render himself unpromotable since his superiors will hesitate to favour one who, clearly, would disturb the even tenor of staff relationships.

Poles apart from the gold-digger is the man who is not as confident of his ability as his superiors' trust in him would seem to justify. This type of situation usually occurs in those cases where an executive is invited to take over an appointment involving unfamiliar duties. It may be that the technical knowledge required seems to be outside the range of the man's experience, or he may feel that the sudden elevation to command of a much larger staff is beyond his powers as a leader. There are two factors worth remembering in these cases: a man is not always the best judge of his own powers and capabilities; and the superiors who have decided to move him will have a vested interest in seeing that he makes good, if only to prove the wisdom of their choice. A certain modesty over accepting promotion or a move to new work and responsibilities shows that you are alive to the importance of the appointment offered, but excessive hesitancy is an insult to your superiors because it is tantamount to saying that they have made a big mistake in choosing you to fill the vacancy.

But what of the people who are passed over, perhaps only temporarily, in the promotions? Some of them, inevitably, will be offended. They are required to accept the new situation and settle down to the revised relationships, and it demands as much grace from them as it calls for courtesy, tact and ability from the promoted. He may start by being distrusted or opposed, but in time he can gain respect, even affection, if he is resolute, patient and competent. If he is seen to have risen naturally—some men seem to float to the top—any opposition will be short-lived. That is why it is important, in the preparatory years, for a man to play his own hand unobtrusively.

By far the most explosive kind of appointment occurs when a man fights his way to a position of authority not primarily for his own benefit but because he sincerely and passionately believes that something urgently requires to be done which is not being done and is unlikely to be done by the man he displaces. He cannot rest for the thought of opportunities lost, valuable time wasted and the future of many people jeopardised. Yet he cannot separate in his mind his personal interests—perhaps also his responsibility to his family—and the interests of his firm which he seeks to serve more effectively. He wrestles with his conscience, he derives no pleasure from the hurt which he does to others, but he is impelled by a force within him which is labelled, shortly and quite inadequately, ambition. Like his reciprocal, the man who resigns over a deeply felt point of principle, he rides roughshod over the conventions of organised life and work. He makes new friends and enemies in the process.

Once in the saddle, however, he has the momentum to carry him over the obstacles which unfailingly confront such a man. As soon as he can, he should take a piece of advice which was offered recently by a well-known engineer who is a director of one of the most famous industrial groups in Britain. Encourage your subordinates, he advised, to take responsibility—and allow them to work you out of your own job. For the man who is fortunate in promotion, that is the best way to show gratitude to those who helped him on the way up, and to atone for the hurt he did to others.

Cover Picture. *The illustration shows the final stage in the winding of the stator for a glandless electric pumping unit. This pump is one of several for installation in research reactors to handle heavy-water coolant. Consequently a high standard of cleanliness must be maintained during manufacture to exclude any grease or other matter which might become radioactive when the pump is in operation.*

* * *

Plain Words

When a man forms an opinion he may be stuck with it for the rest of his life. He should therefore take care to look around a while before he does so. Fortunately minds can be changed, but if the man states his views publicly he may feel obliged to defend them come what may. Policies, because they involve many people, are even more difficult to change, particularly when they are enshrined in protocol.

Practices too often become petrified as policy. An expedient devised to meet a given situation may call for a particular administrative procedure, which later becomes established, or even statutory, leaving no room for manoeuvre when the situation changes. An organisational framework that cannot readily be adapted to new conditions may well become a strait-jacket, so that full advantage cannot be taken of improved methods and processes. An army organised to fight on foot or horseback cannot be mechanised simply by supplying existing units with tanks and charabancs.

Perhaps something of the kind has happened in the development of atomic energy. The Windscale inquiry may reveal not only the need for care in design but also for cohesion in design, planning and organisation. At least, the committee under Sir Alexander Fleck concerned with health aspects of the Windscale accident has called for greater co-ordination between the departments concerned.

In the very early stages of atomic energy there was no body of nuclear engineering and it was necessary to assemble in one team specialists from many conventional technologies. Calder Hall is thus a synthesis but perhaps not a blending of different contributions. Later this philosophy became embodied in the covenant of the British Nuclear Energy Conference, to which the interested engineering and scientific institutions are parties. Perhaps the time is ripe for a new attitude: an engineer engaged on nuclear work may be more effective if he is first of all a nuclear engineer and secondly a mechanical engineer or metallurgist. The Atomic Energy Research Establishment at Harwell has been successfully operated on this basis, and it is significant that the first atomic energy groups to be organised as separate companies were the first to secure power-station contracts.

A practice need not be established 50 years to become sacrosanct, and with to-day's rate of technical advance premature canonisation can cramp development. Knowing when to consolidate is a difficult problem, but to consolidate too soon may be disastrous.

CAPRICORN

Weekly Survey

The New Defence

President Eisenhower's personal influence is said to have suffered and his country's position as world leader may appear to have been temporarily weakened in a single year of dramatic technical and scientific achievement. Yet in his State of the Union message to Congress the United States President authorised a policy which is likely to dominate the relationship of nations and to become the main element in maintaining the balance of power over the next decade. It is a policy which will on the one hand strengthen the economies of the West and on the other quicken the development of what may be called the markets of the West. President Eisenhower's statement is a recognition that the struggle for world influence and leadership will increasingly be fought with economic weapons, though his budget shows that high priority will also be given to military preparedness.

Nuclear deterrents have not been abandoned. Military aid to America's allies will be increased. The development of missiles and of defence against them will be intensified. The budget for the 12 months, ending next June, will be added to, in all, by over 1,250 million dols. The President talks of long-range ballistic missiles, missile sites, missile submarines and missile detection. The United States has plans for nuclear-powered aircraft and for many other technical adventures. There is also the proposal for economic and scientific co-operation with Britain and the other advanced industrial nations of the West. A substantial programme of off-shore purchasing of the latest weapons and equipment is widely expected to materialise in the spring. It should assist these countries in overcoming the threat of an industrial depression.

The most significant point in the President's speech, however, was the declaration that the increased military effort "should not be met by cutting economic assistance." He looked to an extension of economic aid programmes and to an increase in American investment abroad. He advocated a five-year extension of the Trade Agreements Act, "to strengthen world trade." No head of the United States can go too far ahead of popular feeling without risking isolation and defeat. Yet in spirit the State of the Union message was not far apart from Sir David Eccles' remarkable speech in San Francisco in which he advocated an "economic merger" between the United States, the British Commonwealth and Western Europe. Free trade, investment, exploitation of natural resources, development of industry—all are increases which quicken the rise in living standards and increase the ability of the West to influence other nations away from dangerous dictatorships and ruthless political regimes. The President's message gives hope of such a solution to the West's economic, social and political problems and of an effective reply to Soviet Russia's economic challenge.

Knowing When to Scrap

When maintenance costs rise with age there is an optimum time at which equipment should be scrapped. Mr. J. C. R. Clapham, in an article in December's *Operational Research Quarterly*, refers to this time as the "economic life." He points out that the optimum time occurs when the sum of capital depreciation payments and maintenance costs reaches a minimum. Keeping equipment for shorter periods incurs greater expense because of heavier depreciation charges; longer periods have the same result because of rising maintenance charges.

Generally, maintenance costs of machinery do rise with age. A motor car gives an easily recognisable example of this. But the way costs rise varies with different types of equipment. In his article the author shows how to work out the economic life theoretically. First he does it for the general case that holds whatever way the costs vary, assuming only that they increase. Then he works out the simple case where the costs are directly proportional to age. The calculations involve simple calculus.

In the simple case it turns out that the economic life is not critical. An accurate decision when to scrap is not important. Mr. Clapham shows that equipment kept 10 per cent. longer than its economic life has its total cost increased by ½ per cent. The same holds for a 10 per cent. shorter life. Thus it may be well worthwhile to scrap equipment before its economic life, as improved features of new models can offset the slight increase in costs. But the author claims the determination of economic life to be important. He writes: "It is necessary to know the economic life fairly exactly to predict the costs. How long the equipment is then, in fact, kept is a separate matter."

To give a practical example, he produces some figures relating to underground Diesel locomotives. A variety of different installations show a linear increase of maintenance costs with age. In some cases the rate of increase shows that maintenance quality in particular installations could be improved. Mr. Clapham points out that it would be possible to use the method in the design of a quality control chart to check that costs proceeded as expected. Also it enables a quick test to be made whether the costs at any one installation are reasonable.

The Consumers' Share

Changes in consumers' habits of particular interest to the engineering industry are given in the Government's *National Income Blue Book*. Some of the biggest increases have taken place in durable household goods. Production of radiograms increased by 108 per cent. between 1953 and the end of 1956. Television and radio sets on the other hand only rose by 36 per cent. Vacuum cleaners (56 per cent.) and washing machines (61 per cent.) continued the march towards the mechanised home, but the fact that floor polishers increased by a mere 7 per cent. seems to show a retreat from parquet. The production of dry shavers more than doubled during the period. Durable household goods as a whole were about one-third up on 1938, but furniture was only very slightly higher.

Some of the biggest changes come under the heading of private motoring and cycling. The monthly rate of new car registrations rose by 70 per cent. between 1953 and 1955, fell back in 1956, but recovered again by the end of last year. The number of cars on the roads rose by well over a million between autumn, 1953, and autumn, 1956. Motor cycles increased by 288,000 in the same period. At the end of August, 1957, there were over 4 million cars on the road compared with under 2 million in 1938. The volume of expenditure on private motoring and cycling was about two-fifths greater in 1955-56 than in 1938. Other changes in the consumer's habits compared with 1938 are that he bought about one-fifth more food, more cigarettes but fewer cigars and less pipe tobacco, more wines and spirits but less beer. Finally, in spite of television the books bought in 1955-56 were 2½ times as numerous as in 1938; in 1956-57 it was even higher.

Prices for a Coal Surplus

During 1957 coal output rose by 1·6 million tons due mainly to increased open-cast operations. The production of deep-mined coal was adversely

affected by the influenza epidemic which cost about 1½ million tons. This disappointing result on the output side was more than counterbalanced by a surprising and quite severe drop in consumption last year of 5 million tons. This unexpected decline was due mainly to the mild weather followed by a much slower rate in the expansion of industrial activity than might have been expected. The result of all this has been that the Coal Board has been faced with rising costs and falling demand, and a small loss is expected on the whole year's workings.

In addition to the financial loss, the National Coal Board carries over more than 6 million tons of extra coal stocks compared with the beginning of 1957. This is mainly small coal which is not popular either in the home or export markets. Indeed, in the last few months the Coal Board has found that the seller's market on the Continent has quite disappeared and the prospects for exports are not particularly good for 1958.

It is against this background of sluggish demand and higher stocks that the Coal Board faces a demand for higher wages. It is already widely expected that coal prices will be raised this year. Consumers of coal will naturally ask under what conditions it is permissible for a monopoly to raise its prices when demand is falling and stocks are increasing. Normal commercial practice would call for a cut in prices and a stern line on wage demands. There is no indication that this policy will be pursued by the Board although it remains open to the Government to refuse to finance a wage increase at the taxpayer's expense if the Coal Board's financial loss becomes chronic this year. If coal prices are increased to enable the Board to cover its loss and possibly meet the miners half way, the Government will have to explain to the public that such a short-term policy of increasing prices (or alternatively letting the Coal Board operate at a deficit) is permissible since the country needs all the coal it can raise in the long-term. What passes as short-term policy for the coal industry and the Government may well be described by the unfortunate customers, who have to pay the higher prices as users or foot the bill as taxpayers, as an invitation to a nationalised industry to feed inflation.

First Anti-Dumping Order

One of the eventual aims of the Common Market—and presumably the Free Trade Area if it comes into effect—will be to ensure against subsidised goods circulating within it, both from member countries and from outside. Meanwhile, there is a general zeal in western Europe to create anti-dumping legislation, originally stimulated by political pricing of exports from eastern Europe. The British contribution to this fashion has been the Customs Duties (Dumping and Subsidies) Act, which received the Royal Assent on April 17, 1957. Under it, the Board of Trade is empowered to impose anti-dumping or countervailing duties on imported goods of any description which have been dumped or aided by a subsidy and which can be shown to damage a United Kingdom industry.

The first order by the Board of Trade under the new Act has been on an import from one of the members of the Common Market. Representations by United Kingdom manufacturers of silicones have been before the Board since the inception of the Act, and after careful examination of the circumstances, the Board imposed last week an additional duty of 4*s.* per lb. on silicone fluids and emulsions imported from France. France is of course in rather a special position in the Common Market owing to the heavily protected nature of its economy, and the complicated exercises which it performs with subsidies in order to keep its overseas accounts in something approaching balance. So far as dumping is concerned, however, France is in general probably no more guilty than others. Italy, Belgium and the United Kingdom have all been accused of it. Since the Common Market will precede the Free Trade Area (in both of which dumping will be forbidden between members) the temptation to dump on the periphery of the Common Market while they can may be too big a temptation for manufacturers in the Messina countries.

All In It Together

Piecework or bonus schemes based on quality and quantity of work may act as incentives to increased production in some cases, but it is no longer true that they can be relied on generally. There are several reasons for this change, but it is with the cure rather than the cause that production engineers are concerned. If the offer of extra money will not produce the desired result, what will? Mr. Boyd K. Bucey, of the Boeing Airplane Company, speaking in the discussion at the recent Institution of Production Engineers' conference at Southampton, which is reviewed elsewhere in this issue, described a procedure which, if not intended primarily to act as an incentive, does so in fact.

In the Boeing Company it is the practice, before the finished design for a jig is issued to the works, to send a sketch to the departments concerned, and invite comments. Much useful information is obtained in this way: various people will offer suggestions for improvement, or remember past difficulties which may apply to the design in question. These suggestions and criticisms are given due consideration in the design office, and the drawing, modified if necessary, is then issued.

The procedure, which is not so time-wasting as it might appear (nobody is allowed to keep the sketch long), will usually help in the production of a first-class jig, which is, after all, what it is intended to do. But it also has another effect. The jig users have been consulted; they have had their say, and expressed their opinions, good or bad. They feel that it is "their" jig, not just another product of the rather remote people in the drawing office. Consequently, they feel that their opinions count for something in the company, and goodwill is created. Finally, said Mr. Bucey, even if, by bad luck the jig turns out to have defects, the works will not simply refer it to the designers. They have had their chance and missed it; they will make the thing work.

Grants Without Means Tests

The civil engineering profession and industry are jointly to award up to 20 scholarships—worth between £300 and £400 per annum—to enable boys to study civil engineering at a university. Most of the scholarships are expected to go to boys not normally eligible for State grants, such as sons of families where the income exceeds £2,000 a year.

The scheme is being sponsored jointly by the Institution of Civil Engineers, the Association of Consulting Engineers and the Federation of Civil Engineering Contractors and was announced by Sir Arthur Whitaker, President of the Institution, at a conference of school careers masters. Arranged in conjunction with the Public Schools Appointments Bureau, the conference, which was held at the Institution, was designed to give teachers some information on the method of entry and opportunities available in the industry. A panel of speakers—from Government authorities, consultants, contractors and a university engineering department—gave the 100 or so teachers present their individual impressions of what such a career could give a boy. To the question of which would be the best way for the schools to prepare their boys to be engineers, the President replied: "By teaching them to think." Many engineers, however, may ponder on the comment by one of the panel that engineering would develop to the full any abilities that a boy might possess—except that of oratory. There still seems to be a difficulty in specifying the attributes of a boy who would make a good engineer when they fall short of those which would make him good anywhere.

Letters to the Editor

PLAIN WORDS IN PATENTS

SIR, Having from time to time scrutinised patents in my relatively restricted and simple field, it occurs to me to wonder if an application of the title of your weekly feature of December 13, 1957 (page 738), "Plain Words," to the drafting of patent documents might not facilitate the attainment of greater speed.

I realise the possible legal pitfalls in apparently simple and straightforward expressions, but most if not all the patent documents I have seen seem to embody quite unnecessarily inept, obscure and vainly repetitious language.

Yours truly,
R. A. LAURENCE.

76 Scotts-lane,
Shortlands,
Bromley,
Kent.
January 10, 1958.

ORGANISING CONFERENCES

SIR, In his column "On the Shelf" in your issue of January 3 (page 27), Mr. Frank H. Smith refers to the UNESCO Monthly *Bulletin's* "lone campaign to reduce the number of conferences."

He may like to know that the Union of International Associations has been pursuing such a campaign for many years by compiling and circulating calendars of announced international meetings. In providing congress and conference organisers with such data it is hoped that they will be encouraged to take note of projected activities in their own and allied fields, and discuss the possibilities of joint events, instead of arranging independent meetings which inevitably conflict in time or place.

Yours faithfully,
G. P. SPEECKAERT,
Secretary-General.

Union of International Associations,
Palais d'Egmont,
Brussels,
Belgium.
January 9, 1958.

Editor's Note: ENGINEERING also publishes a list of forthcoming conferences, congresses and exhibitions, under the heading "Exhibitions and Conferences," which, among other uses, serves a like purpose to the activities of the body mentioned above. The ENGINEERING list appears in the last issue of each month.

UNDERWATER OIL TANKERS

SIR, The idea of building an underwater oil tanker (ENGINEERING, December 13, page 738) is very attractive—it was once put forward, together with the necessary calculations justifying its economy, by a friend of mine some nine years ago.

The advantages afforded by the lack of wave making resistance at great depths and the favourable cargo-displacement ratio are beyond dispute. I do disagree, however, with your article about the question of propulsion. To obtain low hull resistance the vessel's shape, of necessity, must be a solid of revolution of the type now being model-tested by Saunders-Roe, Limited. Propulsive efficiencies exceeding those of conventional tankers could be obtained by placing the propellers aft on the hull axis in the symmetrical hull wake. To balance the propeller reaction torque, tending to rotate the hull, the propellers would have to be counter-rotating. The design of them could follow the principles used for the design of counter-rotating torpedo propellers.

It also appears to me that the propeller immersion would probably be sufficient to prevent propeller cavitation; in any case, the intensity of any cavitation, which might not be avoidable at 50 to 60 knots, would certainly not be such as to deserve the name of "super-

Continuing Letters to the Editor

cavitation " and the required blade sections would be quite conventional.

Yours faithfully,
F. CIECHOWSKI.

127 Junction-road,
Stockton-on-Tees,
County Durham.
January 5, 1958.

MOTION OF A YACHT

SIR, It is a pleasure to read the special article on page 6 of ENGINEERING for January 3 on " The Motion of a Yacht Through Air and Water," after reading, in books and periodicals devoted to sailing, so many woolly and even downright inaccurate descriptions of how a boat goes to windward.

To my mind, schooled in Newton's laws of motion, it is simpler to consider the ship as in a state of steady motion (i.e., in equilibrium) under the action of only two equal and opposite forces: the total aerodynamic force on the sail (F_S), and the total hydrodynamic force (F_H) on the hull. If these two are subsequently resolved into their respective lift and drag components (L_S, D_S, L_H and D_H), perpendicular and parallel to the respective fluid flows, it is clear (as shown in the accompanying diagram, Fig. 1) that the angle between the course " made good " and the wind, a matter of prime interest to the sailor, is the sum of the angles between L_S and F_S and between L_H and F_H. In other words:

$$\alpha = \beta + \gamma$$

$$\text{i.e., } \alpha = \tan^{-1}\left(\frac{L_S}{D_S}\right) + \tan^{-1}\left(\frac{L_H}{D_H}\right)$$

This brings home the importance of the lift/drag ratio for both sail and hull, rather than the absolute magnitude of these forces.

Another illuminating graphical representation is a polar diagram of speed through the water at various courses made good relative to the wind. Fig. 2 shows a hypothetical one. It is the component of speed to windward that greatly interests the sailor, particularly when racing, and he may see clearly from this diagram that it is not necessarily the " finest " course that can be steered that is the fastest to windward.

In fact, most helmsmen know that " pinching " is a fatal error. This diagram shows why, and it also shows that it is better to err away from the wind than into the wind.

Yours faithfully,
J. SIDGWICK.

40 Glenilla-road,
Hampstead, N.W.3.
January 10, 1958.

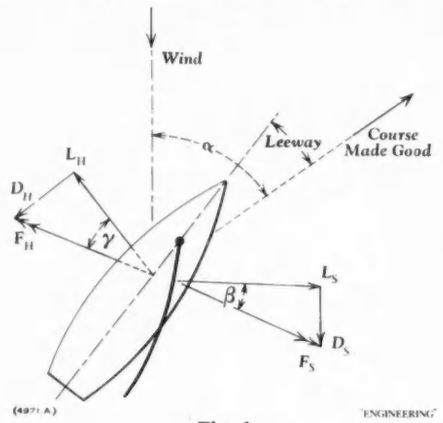


Fig. 1

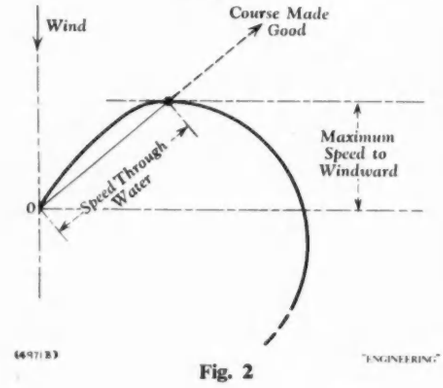


Fig. 2

Obituary

MR. ALASTAIR McLEOD

It is with regret that we record the sudden death, on January 3, of Mr. Alastair McLeod, head of the metallurgical editorial staff of Industrial Newspapers, Limited, John Adam House, John Adam-street, London, W.C.2. He had been associated in an executive capacity with the company's metallurgical journals for 21 years. " Mac," as he was familiarly known to a large number of men in the steel industry and in technical journalism, whom, in turn, he called by their Christian names, was only 58 years of age.

An authority on rolling-mill practice, he received his metallurgical training in his native Scotland and spent the years of his youth and early manhood in the works of Frederick Braby and Company, Limited, Glasgow, and other rollers of sheet-steel products. In 1937 he took up the editorship of *Sheet Metal Industries* and at the time of his death was managing editor of that journal and of *Metal Finishing Journal* and *Metal Treatment and Drop Forging*, and chief metallurgical editor of the *Iron and Coal Trades Review*.

Mr. McLeod was elected a Fellow of the Institution of Metallurgists in 1952 and, last year, was made an honorary vice-president of the Institute of Sheet Metal Engineering, which he was largely instrumental in founding, and of which he was honorary secretary for a number of years. He was also a member of the Iron and Steel Institute, the Institute of Metals, the Institute of Welding, the Institute of British Foundrymen, and the Institution of Production Engineers.

★ ★ ★

ANGLO-SOVIET AIR PACT

As was forecast in ENGINEERING a few months ago, an Anglo-Soviet air pact has been signed covering a civil-airline service between London and Moscow. The route will be confined to the London-Copenhagen-Moscow run and the arrangement is terminable by either side at six months' notice. The agreement was signed by Marshal P. F. Zhigarev, Chief Marshal of Aviation for the Soviet Union, and on behalf of the United Kingdom Foreign Office by Mr. D. Ormsby-Gore, Minister of State; it is terminable by either side at six months' notice. It will be operated by British European Airways and Aeroflot, the Soviet airways organisation, who are to consider commercial arrangements.

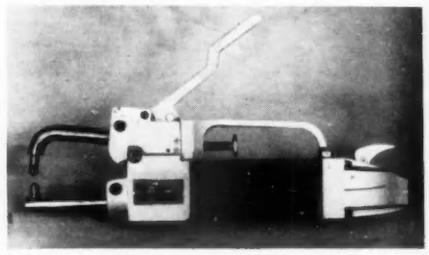
An agreement of this kind involves a wide exchange of technical information on air controls and traffic conventions. There has not been a direct link between the two countries before by air, and both parties will have to examine each other's control techniques. There is nothing basically difficult in this since there are international air communications between Russia and other European countries and technical missions are to be exchanged early this year. On the British side there will be a good deal to learn about climatic conditions and Russian method of air control, which will be complicated by problems of language. Nevertheless, in its small way, the agreement is a means of establishing a method of exchanging highly technical information which may serve in some respects as a pattern for technical arrangements in other fields to come later.

Plant and Equipment

PORTABLE SPOT-WELDER

A range of lightweight and heavy-duty spot-welding machines designed to cover the requirements of such varied industries as those of motor-car body fabrication and repair, sheet-metal fabrication, atomic-engineering applications, aircraft production and shipbuilding, has been placed on the market by Portable Welders Limited. The firm's sales office for the United Kingdom is at 225 Westminster Bridge-road, London, S.E.1, and export sales are dealt with at Castle Mills, Buckingham. The works of the firm are at Denbigh-road, Bletchley, Buckinghamshire.

Among the several machines available at present, the first is the lightweight Leopard Auto-Spot portable spot-welder for general workshop or garage use. It is designed basically for such work as the repair of motor-car bodies, sheet-metal fabrication, unit construction, tack-welding and similar work. Four types of hard drawn high-conductivity copper electrode arms can be supplied for use with the machine. These give a throat depth of up to 13 in. The weight of the machine, without the electrode arms, is 25 lb., and its welding rate, on the BEAMA rating, is 4·8 kVA. The machine, which is shown in the accompanying illustration, has



The Leopard Auto-Spot lightweight portable spot-welder for workshop or general use.

a length, without the electrode arms, of 17 in., a width of 3¼ in., and a height of 7 in. In action, the machine is plugged into a 220-230 volt, 15-20 ampere alternating-current socket. The pressure tong lever on the top of the machine is then pushed down in order to press the contacting electrode tips on to the work and, finally, the trigger switch at the rear of the machine is actuated, thus completing the spot weld.

A second machine, the Leopard S.70 heavy-duty spot-welder, is for production work. It is capable of continuous duty, at average production speeds, on widely differing types of sheet-metal fabrication and wire-mesh work. With a power factor close to unity, the mains-current draw is well below 50 amperes and, in fact, is controlled by a mains fuse of 30 amperes. The hand-operated model has a toggle action, the pressure mechanism giving a tip pressure of up to 600 lb., with an 8 in. throat depth. The welding rate (on the BEAMA rating) is 8·5 kVA. For production work, this machine is used with water-cooled arms and usually in conjunction with electronic timing apparatus, giving welding periods of from $\frac{1}{25}$ to 1½ seconds. The machine can also be fitted with a sling, giving a turning circle of 180 deg., and a balance which enables the operator to hold the machine in the exact place required with the minimum of effort.

For still heavier work the Leopard S.100 machine has been produced. This is basically similar, both in design and operation, to the S.70 machine, but it has a welding rate of 10 kVA, and is capable of higher production speeds, especially when fitted for pneumatic operation.

Advantages claimed for the S.70 and S.100 machines are that they are capable of the heaviest work demanded of a spot-welder and that they can be taken to the job and used in places difficult of access to normal welding equipment.

A GEAR TRAIN WITH NO BACKLASH

During the war the application of servo controls to existing naval gun mountings disclosed serious shortcomings in the drives, which had been designed for hand, or hand/power control. Detailed investigations showed that the performance obtainable from the drives was limited by high yield/torque, or by low torsional stiffness of the driven member, the latter being particularly important where the member has a high inertia. A considerable part of the yield was found to be taking place in the gear trains and boxes, and attention was directed towards the improvement of both the design of the gear trains and the production techniques used in the manufacture of the components. The results were very successful, and it is now possible for a servo designer to specify and obtain a gear train which is virtually backlash-free, and has a very high stiffness. As a natural corollary of the overall improvement in the gear train, from input to output, there is an equal improvement in the intermediate take-off points, which may be used for driving Magslips or tachogenerators, the improvement being reflected in more accurate and consistent reference of angular position or speed.

In meeting ordnance requirements the designers of the gear train have produced a mechanism which is likely to find applications far beyond the ordnance field. For this reason the John Thompson Ordnance Company, Ettingshall, Wolverhampton, have decided to undertake the design and manufacture of gear trains having the characteristics of their gun-mounting gearboxes, but adapted as required to industrial needs. The techniques developed are already being used on certain parts of the Berkeley nuclear power station charge face equipment.

The gearbox illustrated herewith, which was designed and built for a specific gun mounting, is typical of the equipment in question. An overall ratio of 400 to 1 was required from motor to load; of this a figure of 18 to 1 was accounted for by the final rack and pinion drive on the mounting. It was not necessary to provide a hunting tooth. The maximum h.p. developed is about 1·125, but owing to the possibility of instability occurring in the control, the teeth of the gears are very lightly loaded by this duty.

The aim as regards drive stiffness was to achieve a frequency of greater than 10 cycles per second under conditions of maximum mass inertia of the load. It was decided that the gearbox should be bolted firmly to the rotating structure of the mounting, so gaining rigidity, and, by making provision for final adjustment of the pinion/rack mesh, to minimise backlash at this point. With this in mind it was considered desirable to aim at a gearbox drive stiffness which would give a natural frequency of not less than 20 cycles per second, and preferably more than 30. Design requirements called for a fine Magslip to be driven at a ratio of 36 to 1 in relation to the load, for an overspeed centrifugal switch, and for a limit switch coupled to the final shaft. Lubrication by built-in pump was also specified. The layout decided upon is shown in the accompanying diagram.

DESIGN DETAILS

Admiralty gearing specifications for precision gears for control systems provide for four classes of gear, ranging from Class 1, which requires a very high degree of accuracy in manufacture, to Class 4, which is suitable for general engineering applications where backlash is permissible. Detailed manufacturing tolerances and methods of testing are specified. It is obviously desirable to use the lowest class of gearing possible, consistent with obtaining the desired performance and, in the case of the gearbox under review, the gears are arranged in pairs, Class 3 for the first reduction and Class 2 for the output and Magslip drive end of the box. The gearbox, which is of fabricated steel construction, is designed for jig boring under production conditions, and the shaft centres are fixed. Standard "O" and "OO" fit ball and roller bearings are used for the shafts, except for the pinion end of the output shaft, where Timken double tapered roller bearings, held on the shaft and free to slide in the housing, are used. A bevelled eccentric mounted on the output shaft drives a simple, single-plunger type lubricating oil pump, which is immersed in the oil tank.

Experience has shown that gears can be cut to the required tolerances by shaping or hobbing on selected machines with selected tools, and the gears for the present box were cut in this way. The materials used are limited by the method of manufacture to an ultimate tensile strength of 60/65 tons per sq. in.

TEST RESULTS

Each gear was checked for accuracy after cutting, by running it in mesh with a master gear, and measuring the radial displacement caused by the accumulative errors, that is, run-out, profile, pitch and accumulative pitch errors. A typical Class 2 gear is the 10 in. pitch circle diameter, 10 diametral pitch gear of 50 tons per sq. in. tensile material on the output shaft. The specification calls for an accuracy of $^{+0\cdot0005}_{-0\cdot0016}$ in., with respect to the exact tooth profile on the nominal pitch circle diameter during a full revolution of the gear. On the gear in question the maximum composite error is 0·0014 in. and the maximum tooth to tooth error is 0·0007 in. The gear centre requirement was a tolerance of $^{6\cdot0008}_{6\cdot0000}$ in., which is met without difficulty on production runs. It is of interest to

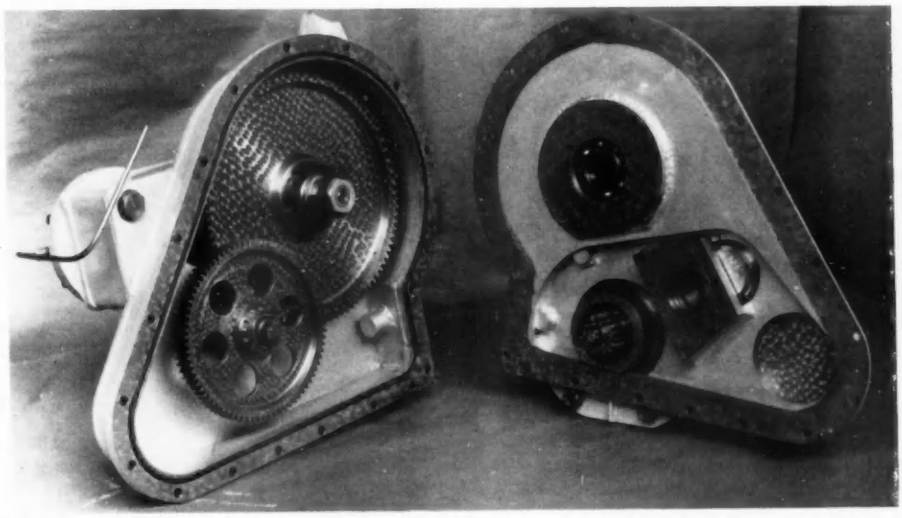


Fig. 1 John Thompson gear train designed for ordnance work, but available for industrial applications requiring freedom from backlash.

Fig. 2 (below) Diagram showing sizes and ratios of gears and layout of box.

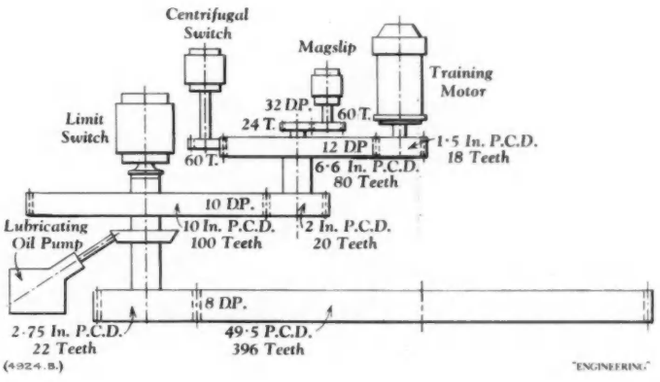
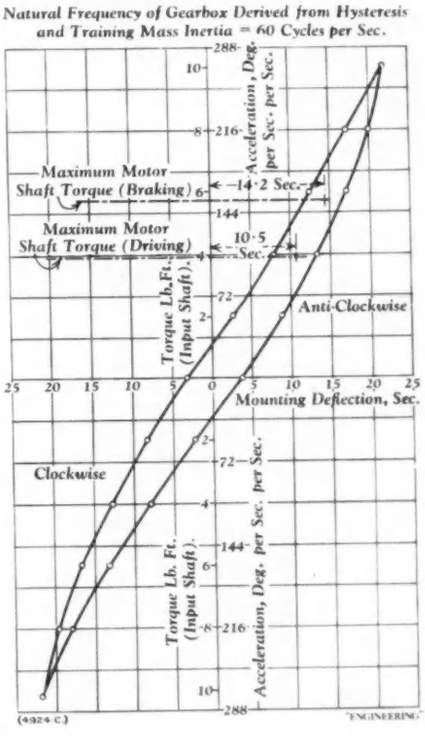


Fig. 3 (right) Hysteresis diagram giving results of tests on finished gear train.



Continuing **Plant and Equipment**

note that the accuracy indicated by these figures, which was adequate for the particular application, was by no means the highest that can be obtained. Class 1 specification calls for total composite errors of 0·0007 in., and production gears in this class range between this and 0·0004 in.

After assembly the output pinion was locked relative to the box at the position of maximum backlash, and the input pinion, mounted temporarily on a dummy shaft instead of on the drive motor, was loaded through a lever on the shaft. The degree of rotation of both the input and output shafts was then determined by means of dial gauges at known radii, and from these readings the hysteresis diagram reproduced herewith was prepared. Taking into account the accuracy with which the final rack can be cut and located to its double ball bearing track, it is considered that the probable overall drive backlash of the complete 400 to 1 drive would be about 18 seconds, and the natural frequency greater than 30 cycles per second. The maximum cyclic error of the box was determined by rotating through 360 deg. of the output pinion and referring the input and output shafts positionally to each other while they were loaded by a constant torque device in both directions. A figure of 3·3 seconds of arc referred to the load was obtained, and this is more than adequate for gun accuracy.

INDIAN LOCOMOTIVES

As a result of the vast increase in suburban and main-line traffic in the industrial belt of Bihar and West Bengal the Indian Railways decided to electrify the lines at 3,000 volts direct current. For this system, the first of the 12 locomotives made by the English Electric Company, Limited, Marconi House, Strand, London, W.C.2, has been completed. These locomotives, known as the EM/2 class, weigh 111 tons and are rated at 3,120 h.p. with a top speed of 70 m.p.h. Each of the six axles is driven. A feature peculiar to Indian Railways is that the controls are so arranged that any one motor can be cut out of circuit while the remainder can still be run up to the series full-field connection.

The locomotive consists of a single superstructure carried on two three-axle bogies in which each axle is driven through single-reduction resilient spur gears by a nose-suspended axle-hung traction motor. There is a driving cab at each end and the locomotive can be driven in either direction of travel. Access is provided to each driver's cab by means of doors on both sides of the locomotive and through communication is achieved by a central corridor.

The driving position is located at the left-hand side of the cab where the master controller, brake handles and driving instruments are arranged within easy reach of the driver. The assistant's position is at the right-hand side of the cab adjacent to the hand-brake.

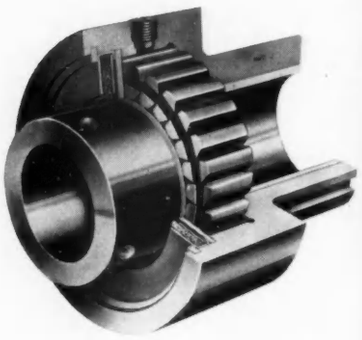
The high-tension control equipment is housed in two equipment frames mounted in the main body compartment together with the two main starting resistance frames and the two motor generator sets. Each high tension frame forms a compartment with bulkheads, and the locomotive side doors and the access doors in the cab bulkheads are mechanically interlocked with the pantographs and main earthing switches.

Both bogies have side frames of rolled steel plate, flame cut and machined to profile, secured to fabricated steel transomes and head-stocks by means of driving-fit bolts. The superstructure is carried through the centre pivot on to an annular bearing surface on the fabricated double bolster.

ONE-WAY CLUTCH

Renold Chains Limited, Wythenshawe, Manchester, are now making under licence the sprag clutches developed by the Formsprag Company of Detroit. A cutaway example of a typical model is shown in the accompanying illustration.

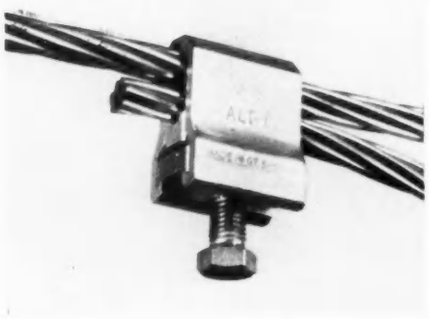
The action is simply that a series of metal sprags mounted between the two races is constrained by a helical spring so that they always tend to expand between the two races. Over-run is thus permitted but any movement in the opposite direction causes the sprags to grip immediately. Models are available for either sleeve or ball bearing shafts and in a range of sizes from ¼ in. bore to 12 in. bore; the latter has a torque capacity of 136,000 lb.-ft.



Formsprag clutches have torque capacities up to 136,000 lb.-ft.

OVERHEAD CONDUCTOR TAP

A new line tap for overhead conductors is being made by the Aluminium Wire and Cable Company Limited, 30 Charles II-street, St. James's Square, London, S.W.1. It is called the Awco saddle tap and is designed for non-tension service connections on all forms of aluminium conductors. The illustration shows the tap in use.



Two-piece construction is used in the Awco saddle tap, which has a continuous current rating of 60 amp.

Two-piece construction is used. The fittings are of high-strength corrosion-resistant aluminium alloy, the screw threads being anodised to prevent seizing. Special tools are not required. The saddle taps are available in two sizes: ALT-1 for conductor diameters between 0·177 and 0·366 in.; and ALT-2 for diameters between 0·367 and 0·558 in. The continuous current rating is 60 amp.

FRESH WATER FROM SALT

CONTINUOUS HIGH OUTPUT FLASH EVAPORATOR

Evaporators capable of producing high purity distilled water from sea water at the rate of hundreds of tons per day are not in themselves new. But they have in the past tended to be both bulky and costly, and have required a good deal of attention; moreover, it has usually been necessary to shut them down at intervals so that deposits on the heat transfer surfaces can be removed.

It is claimed, however, that the evaporator now being made by Richardsons, Westgarth and Company, Limited, Wallsend-on-Tyne, has succeeded in either mitigating or removing altogether most of these difficulties. However large the output, the whole of the plant can be arranged in a single vessel. This results in considerable economies in space and cost, and eliminates much external pipe work. Operating methods have been developed ensuring that deposits are negligible, and that they accrue in the form of a thin layer of soft powder; means are provided for washing this off the tube surfaces without interrupting the operation of the evaporator. The plant can, if necessary, be made completely automatic and requires little attention or maintenance.

The performance figures are based on long periods of operation on a large test rig using sea water as raw feed. Evaporators can now be offered for any duty within the range from 10,000 to 500,000 lb. of distillate per hour with an output ratio (lb. of distillate per lb. of steam) of from 2 : 1 to 7 : 1. These figures are based on sea water feed, but the evaporator is equally suitable for distilling softened water and, with this, higher maximum operating temperatures can be used with consequent higher outputs from a given size of plant. The heat supply is usually low grade sub-atmospheric steam at a minimum pressure of 11 lb. per sq. in. abs.

The method of operation is shown schematically in Fig. 1. Brine is circulated by a pump through a series of heat transfer surfaces where it is gradually heated by condensing vapour, produced in a series of associated flash chambers. The final heating is normally achieved by an external heating steam supply in the heat input section. The boiling brine is finally cascaded through the flash chambers, which operate at progressively lower pressures and saturation temperatures. In the process some steam is flashed off in each chamber and it condenses (as distillate) on the heat transfer surface associated with each chamber.

The heat rejection from the system is normally effected by a separate cooling water supply to the heat transfer surfaces operating at the lowest temperature and pressure. Most of the cooling water used there is ultimately rejected, but a portion of it (normally of the order of 200 to 220 per cent. of the distillate made) is discharged as feed into the low pressure flash chamber. The excess brine is continually discharged from the system through the blow-down valve. If the feed is 200 per cent. of the distillate production then the blow-down will be 100 per cent. of the distillate made, and the brine that is circulating in the evaporator will be brought to double the normal concentration of sea water. This is the normal design figure for the plant, except when very high distillate purities are required.

The distillate made in each heater is cascaded from stage to stage and is extracted from the last stage by a pump. The condensate produced in the heat input section is normally also cascaded through the heaters, and is extracted from the plant together with the distillate.

If an adequate sea water supply under pressure is available, only the brine circulating and distillate extraction pumps shown on the diagram

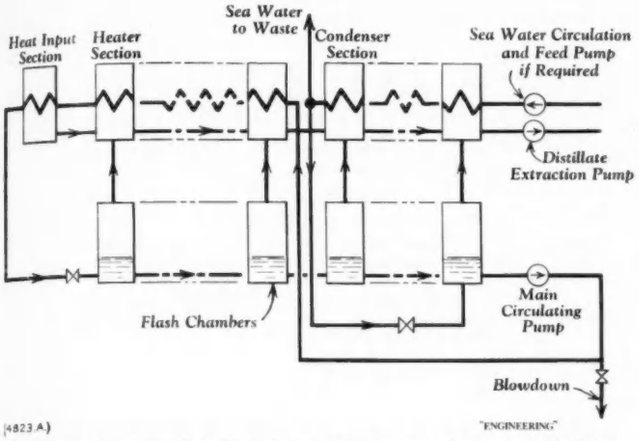


Fig. 1 Brine cascaded through a series of flash chambers is distilled to produce fresh water with a purity greater than 50 p.p.m.

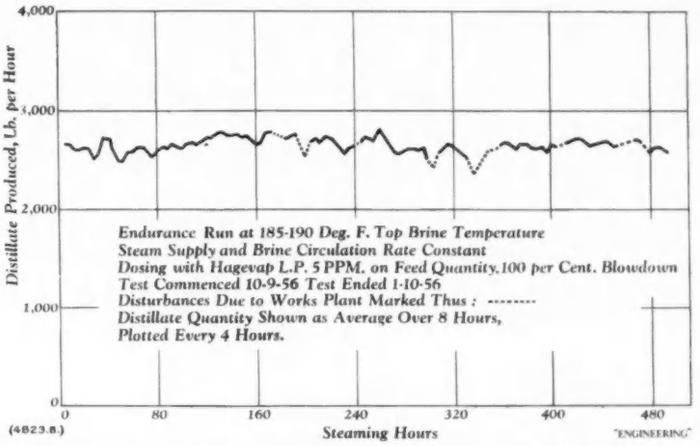


Fig. 2 Continuous operation for long periods is possible with the production of only very small deposits of soft sludge.

are required for the operation of the plant. An ejector or a vacuum pump is also needed to maintain the requisite vacuum.

The heat transfer surfaces of the plant are generally straight aluminium brass tubes, attached to rolled naval brass tube plates. Where the sea water supply contains sand or other erosive material, the use of cupro-nickel tubes may have to be considered. The heaters and flash chambers of the plant are arranged inside a fabricated mild steel vessel and the arrangement is such that apart from the heat transfer surfaces the vessel does not contain any internal piping or ducting of any sort. The whole of the plant is generally arranged inside one vessel and does not require any additional external heaters, coolers, flash chambers, etc., except for the ejector condenser, which is generally separate. Regardless of the net gained output ratio, more than one vessel is used only if transport and erection, or other similar considerations, make it necessary. It may, however, often be convenient to arrange the heat input section in a separate vessel. The plant is arranged, together with the required pump units and other ancillaries, to give easy accessibility for servicing and to have a minimum of external piping.

SCALE PREVENTION

The prevention of scale in operation is a most important problem in industrial sea water evaporators which have to be operated continuously with little or no outage or reduction in output due to scaling. Tests were therefore carried out on a full size industrial pilot plant rather than laboratory size rig. All the development work was carried out by treating the sea water feed into the plant with 5 p.p.m. of Hagevap LP, marketed in this country by Albright and Wilson. The compound is a powder which dissolves readily in water, and it is fed into the pump suction through a needle valve and a Rotameter, where the flow is proportioned to the feed flow. The running cost of the treatment is of the order of a halfpenny per ton of distillate produced. The powder is also a mild corrosion inhibitor, and the circulating brine, after treatment, is still strongly alkaline.

It was found that, without completely suppressing the formation of deposits, the treatment was operationally successful provided that the brine was not heated in the evaporator above the figure specified for normal operation, namely 180 to 185 deg. F. (84 deg. C. approximately). The treatment was proved in over 1,500 hours test rig operation, and the graph, Fig. 2, shows the results of a 500 hours run with a constant steam supply, and constant brine circulation, with a maximum brine temperature of 185 to 190 deg. F. (87 deg. C. approximately), that is, 5 deg. F. higher than specified. The disturbances shown in the graph were due to other demands on the available steam and vacuum services. Deterioration only increases slowly with increase of temperature and the only penalty for such operation will be the necessity for an increase in the frequency of washing out.

The very slight deposits produced in the tubes after prolonged running using Hegavap LP treatment and with low temperature operation consist of a very thin layer (less than 0·001 in.) of a soft sludge, as opposed to the relatively thick hard scale produced by untreated sea water at high temperatures. These deposits can be brushed off with ease, but methods have been developed for washing them off while the evaporator is in service, without interrupting operation. However, the presence of organic matter, marine life, algae, sewage, and abrasive material will cause fouling or erosion as in a conventional condenser.

A simple type of moisture separator has been developed for the flash chamber design used, to ensure distillate purities ranging between 10 p.p.m. and 50 p.p.m., depending on design conditions. In general, the better purity figures are achieved at the expense of lower plant loadings and increased cost of the separators. The latter are manufactured from copper sheet as individual units and are mounted on simply arranged water seals, so that removal for inspection is easy. This purity is adequate for normal drinking water supplies and for feed water supplies to low pressure boilers. Where the bulk of the output is required for feeding high pressure boilers, a different type of separator has been developed, which will ensure very much better distillate purities.

For installation where the heating steam is provided from high pressure boilers, a separate condensate extraction pump can be arranged to extract the pure condensate from the heat input section without mixing it with the bulk of the drinking quality distillate produced. Arrangements can also be made for a proportion of the distillate stream to be produced to very much higher purity requirements than the bulk of the output, and to be extracted, as boiler feed make-up, together with the heating steam condensate.

AUTOMATIC CONTROL

Once vacuum has been raised and the plant has started production, the operator has only to set the distillate production rate by adjusting the brine circulation, the heating steam and feed flows and the Hagevap LP dosing flow, in that order. The blow-down is automatically controlled. The plant can be arranged for semi-automatic or fully automatic operation, so that it can be run without attendance.

The evaporator is designed for heating with any low grade steam supply available, 11 lb. per sq. in. abs. being the lowest economical steam supply pressure. A small quantity of steam at a higher pressure is generally required for operating the air ejectors, although other methods of venting the plant are available.

In many installations, particularly for large outputs of distilled water, it is expedient to combine power generation with the production of water, by the use of a medium or high pressure boiler installation, combined with back-pressure or pass-out turbines feeding the evaporator. In other cases heat may be available in streams of hot exhaust gases, as from a gas-turbine installation, from refinery operations, etc. Such arrangements will often be cheaper than a conventional waste heat boiler installation.

TRUE-PERSPECTIVE DRAWING BOARD

Subjects Reproduced in Three-Point Perspective

The increasing use of perspective drawings in the engineering industries has led to the introduction, within the past two or three years, of apparatus specially designed to facilitate and expedite the production of such drawings, which otherwise is a time-consuming process and a highly skilled one. Generally, these perspective drawing instruments, designed for high-precision and speedy work, have been rather complex and correspondingly costly. Recently, however, Mavitta Drafting Machines Limited, Highlands-road, Shirley, Solihull, Warwickshire, have introduced a " 3D " drawing board which is of comparatively low cost, well within the means of any drawing office likely to be concerned with perspective work. The 3D board is the result of four years' development and extended service trials in the illustration department of one of the largest aircraft firms in the United Kingdom.

The Mavitta 3D drawing board has three measuring lines imprinted on it, and intersecting at the focal point. Each line is marked in units that diminish in accordance with the rules of perspective. Three transparent straight-edges slide along the arc-shaped sides of the board. The drawing surface of the board is mounted on a base which allows the board to be turned to six positions. Thus, the subject can be drawn from any of six different angles of view and is reproduced in three-point perspective, that is, with the " vertical " lines also converging on a vanishing point. The illustration can be plotted fully from plan and elevation views, or from the object itself. Alternatively, the details can be added in freehand after the main guide lines have been fixed.

Complete in itself, the 3D board has no complicated parts and can easily be slipped over a normal drawing board. Its use is readily mastered by the average draughtsman with no previous skill in perspective illustration.

Special Article

RAILCARS WITH POWER TO HAUL

Ulster's New Passenger and Freight Service

There are two main points of interest in the Diesel railcars that are now going into service with the Ulster Transport Authority—points rendering them distinct from any now in service. One will appeal particularly to the operating department and one to the engineer and to the cost department. The first is that the cars have engines strong enough to haul light freight vehicles when passenger services are not in demand (or extra coaches in holiday time) and the other that, by the use of automatic gear changing combined with a torque converter, approximately constant horse-power is available at the rail over a wide range of speed, while the engine runs at nearly constant speed for most of the time—the ideal condition for a compression-ignition engine. Moreover, the gear changes have been chosen so that the torque converter runs close to its peak efficiency throughout the range.

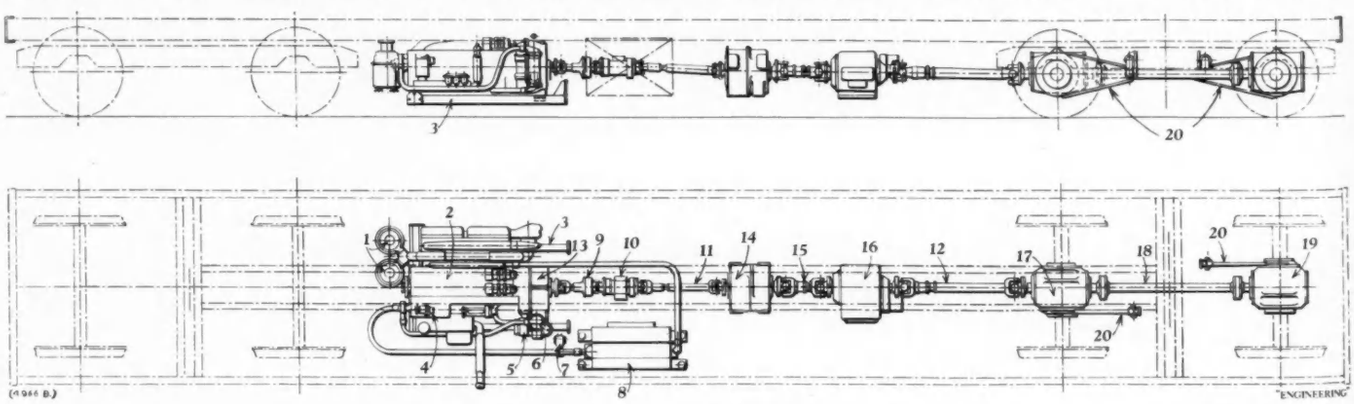
The development of the railcar, and for that matter also of the multiple-unit indivisible set, has long been regarded dubiously by operating managers because it was not possible to attach additional vehicles to the train according to the traffic requirements. For a multiple-unit set nothing short of another complete set could be attached, and most railcars had only enough power to propel themselves—at least if any reasonable speeds were to be maintained and the power unit not grossly overloaded. Consequently the haulage of freight or mixed trains necessitated the use of locomotives which, of course, represented additional initial costs, overheads and maintenance, as well as the irritation of having equipment not used to the full extent possible. The developments in Ulster show one way of meeting these problems.

The scheme originally put forward by Mr. James Courtney, the chief engineer of the Authority, was therefore for power cars that would be capable of hauling a tail load of 200 tons. The idea was followed up by Leyland Motors Limited and Self-Changing Gears Limited, through British United Traction Limited, who proposed to use their 230 h.p. 15 litre engine, super-charged to 275 h.p., in conjunction with a torque-converter and a four-speed planetary-type epicyclic gearbox fitted with an entirely automatic gear-change mechanism. Two complete units, each driving two axles of one bogie, would be mounted below the floor of a power car, giving a unit of 550 h.p. with a tractive effort of about 20,000 lb. The specification called for a single power unit capable of starting a train of 100 tons from rest up a gradient of 1 in 75.

For the purposes of development it was agreed to have only one engine in each power car, an arrangement that allowed of easy access to the various components, also for more or less standard items to be used. As a result, the train used to demonstrate performance to the Press recently was made up of four power cars and one trailer, with three other coaches added for the starting and hauling trials. The five-car set weighs approximately 184 tons for an installed horse-power of 1,100.

The tests were carried out on a stretch of line outside Belfast where there is a long bank rising from 1 in 100 to 1 in 75. When the eight-car train was well on the steepest portion, two of the four power units were stopped, giving the effect of 550 h.p. hauling 200 tons. The train started easily from rest although the rails were slippery as a result of a night frost following rain, and a balancing speed of 15 m.p.h. was achieved very quickly. This was held without difficulty to the top of the bank. The gross weight of the eight cars was about 280 tons. With the starting trials there was also a series of acceleration tests during which a speed of 30 m.p.h. was reached in 30 seconds from a standing start on the level. Subsequently the five-car set was taken over the route that it is intended to run in regular service, namely from Belfast to Londonderry via Castle Rock, and at one point, with a falling gradient, a speed of 90 m.p.h. was attained. Even at this speed the riding was good. Apart from the indicators and a slight change in engine beat when stepping up from first to second gear (only noticeable when it was watched for), the gear changes were not perceptible at any time either during the starting and accelerating tests or

Fig. 1 The multi-purpose Diesel trains of the Ulster Transport Authority can be used for high-speed passenger service, as here, or the power cars can be detached to haul light freight vehicles.



1. Engine air filters
2. Engine
3. Engine mounting sub-frame
4. Hydraulic pump for fan drive
5. Throttle motor
6. Torque converter fluid cooler
7. Thermostatic controller for fan and shutter operation
8. Radiator, fan and shutters
9. Freewheel shaft
10. Auxiliary drive assembly for dynamos and air compressor
11. Propeller shaft—auxiliary drive to bi-directional gearbox
12. Propeller shaft—gearbox to final drive
13. Torque converter
14. Bi-directional gearbox
15. Propeller shaft—bi-directional to four-speed gearbox
16. Four-speed gearbox
17. Inner final drive
18. Propeller shaft—inter-axle
19. Outer final drive
20. Torque reaction members

Fig. 2 In the prototype cars only one engine and transmission unit is mounted. The final plan is for two units giving 550 h.p. per car.

during the run to Londonderry. On the return journey opportunity was taken to observe the exchange of tablets (the route is single track for much of the way), which was carried out quite successfully at speeds of 70 to 75 m.p.h., the normal cruising speed of the train. In service the timing will be 105 minutes for the 93 miles, including five stops.

For use with the railcars, four 10 ton covered vans are having through pipes and connections fitted so that they can be placed between two power cars and through control of both be maintained. The Authority intend to make the best possible use of the sets and hope to run them for 600 miles during each 24 hours for at least five days a week. The arrangement is particularly suitable for their services as the freight handled is mostly light, and what is almost an express parcels service meets the majority of the needs. In all, eight of the prototype power cars are being built in the Authority's workshops at Belfast.

In the layout of the prototype cars (which are being constructed from old steam stock) standard units have been used as far as possible. As was indicated earlier, the final plan is to have two engines and their transmissions under each car to give a total of 550 h.p. Some rearrangement is obviously necessary from the scheme shown in Fig. 2, and designs have been prepared. One proposal is that the reversing gearbox and the change-speed box should be combined, and another is that the drive should be taken from the gearbox first to the outer axles and then back to the inner axles. Investigation has shown that there is space for the latter arrangement. Meanwhile, running experience is being gained with the prototype units.

ENGINE DETAILS

The engines used are Leyland six-cylinder horizontal direct-injection units fitted with Holset turbo-chargers. Bore and stroke are 5·5 in. and 6·5 in., respectively, giving a cubic capacity of 926·2 cub. in. or 15·2 litres. The rated value of 275 b.h.p. is developed at 1,800 r.p.m. and the maximum torque of 840 lb.-ft. at 1,300 r.p.m. These figures have been obtained with the very moderate brake mean effective pressure of 136 lb. per sq. in., so the engines are lightly rated. The compression ratio is 14·8 to 1. C A.V. injection equipment is employed.

The cooling water is circulated by a gear-driven centrifugal pump first through the torque converter cooler then to the oil cooler and so to the liner, cylinder heads and main jacket before leaving through the water manifold at the top of the block. It then passes through the radiator and back to the pump.

In the Serck type radiator which is mounted longitudinally under the coach, the water flows in horizontal tubes. The rate of cooling is governed by a fan and thermostatically controlled shutters. The fan is driven hydrostatically using the Behr system, from a positive displacement pump driven from the engine. A temperature-sensitive controller governs both the speed of the hydraulic motor and the opening of the shutters, which are also hydraulically operated. The thermostat is set for a water temperature at the engine inlet of 85 deg. C.

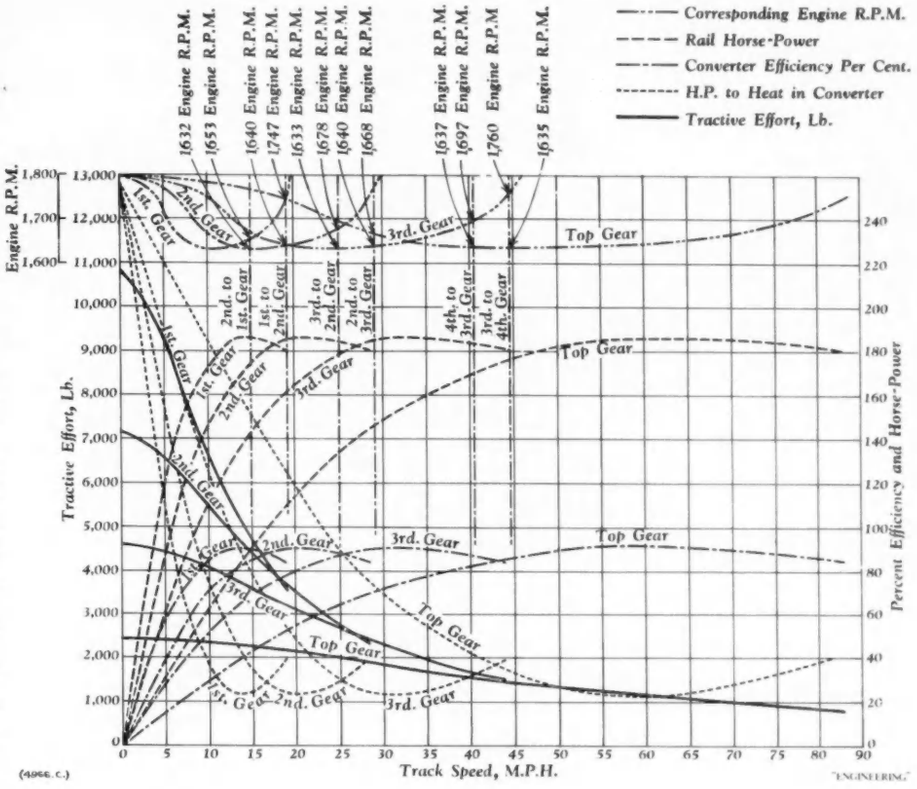


Fig. 3 Performance curves for a complete unit. The engine power has been reduced by 7½ per cent. to allow for the auxiliaries, and the overall mechanical efficiency counted as 85 per cent. Wheel diameter is 43·5 in.

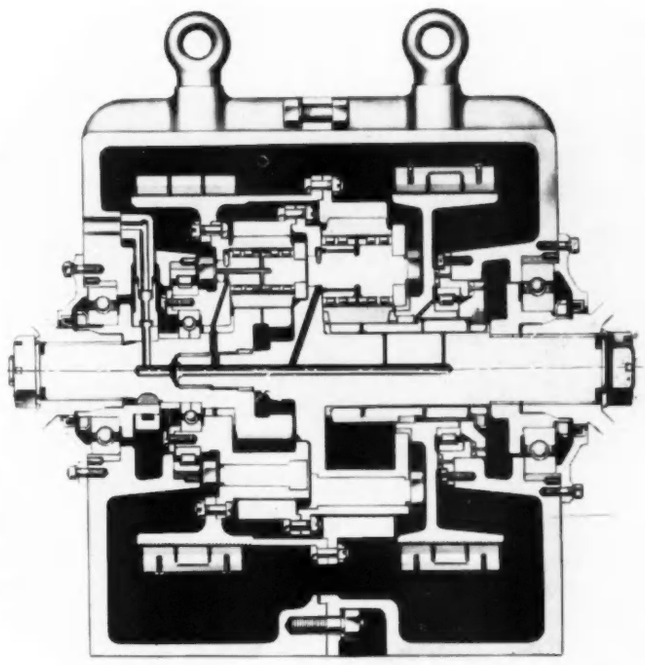


Fig. 4 Epicyclic gears are used for both the reversing box, shown here, and the main four-speed box. The latter is automatically operated according to the speed and torque.

DRIVE

The engine is coupled directly to the torque converter which is of the Schneider type with a stalling ratio of 3·05 to 1. It was supplied by Self-Changing Gears Limited. It is a standard unit rated for 400 h.p. at 2,100 r.p.m. and weighs 450 lb. Tests have shown that it can be stalled for two minutes without any dangerous rise in fluid temperature. The fluid is drawn from a 20 gallon reserve tank by an engine-driven gear pump, and after passing through the converter returns to the tank through the cooler already mentioned. The use of the subsequent four-speed gearbox with automatic selection allows the converter to run at or near its maximum efficiency over a very wide range of vehicle speeds. This keeps the cooling requirements to a minimum as very little power is dissipated as heat.

The propeller shaft that takes the drive from the converter to the auxiliary assembly incorporates a roller-type free wheel so that the car can be moved without power on the engine and can also " coast " on suitable stretches of track. The auxiliary drive assembly, which follows next in the transmission line, comprises the pulleys for driving the air compressor and for two dynamos. This arrangement means that the auxiliaries are continuously driven either by the motion of the train or by the engine, even when the latter is in neutral gear.

The next item in the drive is the reversing gearbox. This unit, designed and produced by Self-Changing Gears, has a reduction ratio of 2 to 1 in both forward and reverse directions. It uses epicyclic gears controlled by air-operated band brakes of the double overlap type. An interlock prevents a gear change while the vehicle is in motion. The box is shown diagramatically in Fig. 4.

Following the reverse box is the four-speed box, also produced by Self-Changing Gears. Again this is of the epicyclic type but differs from standard units mainly in that, since it follows the reversing gox, the brake bands are required to operate in both directions of motion. The ratios, which are 2·33 to 1; 1·55 to 1; 1 to 1; and 1 to 1·87, giving an overall range of 4 to 1, have been kept fairly close to ensure that the maximum operating efficiency of the whole system

Continuing Ulster Railcars

is maintained through the range of vehicle speeds and engine loads. The operation of the bands has been designed to overlap enough to give very smooth and positive changes. A gear pump mounted on the front casing and a plunger pump driven from the output shaft ensure adequate lubrication.

The final drive to the axles is by two spiral bevel units, one for each axle, with ratios of 2·14 to 1. From the inner axle a second bevel gear transmits the drive to the propeller shaft linking the two axles, the bevels being mounted on opposite sides of the bogie centre line to synchronise axle rotation. An axle-driven gear pump delivers oil to the bearings and sprays the gear wheels. The units are axle-mounted with a plate-type torque arm to take the reaction.

One of the main precautions to ensure that the torque converter and engine are run at their maximum efficiency for as much of the time as possible, is the automatic gear-changing mechanism. This operates on the V.S. system and the changes are governed by a combination of the speed and torque at any one time. (Curves showing the performance obtained are shown in Fig. 3.) As a result, the engine runs at almost constant speed over the greater part of the range of vehicle speeds and a constant power output is obtained. This in turn results in maximum acceleration and sensibly constant rail horsepower in which gear-changing is almost imperceptible. Moreover as the engine runs under steady thermal conditions (and since in this particular case it is rather lightly rated) its life should be long and maintenance kept very low.

To operate the changes there are two generators driven from the output shaft of the change-speed box and a relay panel in the driver's cab. As the generator voltage rises and falls with the speed of the vehicle, the relays open and close in sequence, energising the electro-pneumatic valves which select the appropriate gear ratio. The pattern of gear-changing is modified by the position of the throttle so that higher gears are used at lower speeds with reduced throttle openings. Thus the driver is not concerned in any way with the changes of gear that must be made.

The driver's controls therefore consist of the engine control switch and the transmission controller, which is a dual switch providing both gear and direction control. The first has four positions in addition to idling and incorporates the deadman's handle in its assembly. The gear switch has two positions only, drive and neutral, the automatic selector looking after the speed changing as has been described. The direction switch has three positions, neutral, forward and reverse, and is operated by a detachable handle which can only be inserted or removed when the switch is in the neutral position. A mechanical interlock between the gear and direction switches prevents a movement of the latter while the gear handle is in the drive position. The handle of the direction controller is also used for the battery isolating interlocking switch.

Two vertical panels, one on each side of the driver, carry the instruments and gauges, including a wheel-slip indicator. Wheel slip is indicated when the needle of the instrument is appreciably out of phase with the needle of the speedometer; the instrument is train-wired to the V.S. control generators and indicates slip for any drive unit in the train. Provision is made for the automatic shut-down of engines under conditions of loss of coolant, a drop in oil pressure or fire. It is effected through the engine isolating trip switch which isolates the starter circuit and energises the stop solenoid.

In addition to the normal controls in the driver's cab, each engine can be started or stopped at track level by push buttons located on the underframe of the car. Push buttons are also provided to enable any engine to be isolated from the local and train controls. After an automatic shut-down or the isolation of an engine from track level, the isolating switch must be reset by hand before the engine can be re-started.

Metals and Materials

HIGH-ENERGY SOLID ROCKET FUELS

Although the solid-fuel rocket has been steadily gaining ground over the liquid-fuel rocket as a power plant for missiles, on account of its greater ease of handling under field-service conditions as well as its mechanical simplicity, its use has so far been mainly limited to the shorter-range missiles. Now, however, it is learnt that a high-energy solid rocket fuel, probably based on decaborane, is being developed in the United States which, it seems likely, will put up the range capabilities of the solid rocket at least into the " intermediate " class.

The potential performance gain when burning high-energy fuels depends upon their effective oxidation; in the case of air-breathing engines it is very considerable. In the case of solid propellants, however, there is the problem of introducing sufficient oxidant into the propellant mixture to liberate the available heat properly. The problems of binding an extremely large proportion of oxident, such as ammonium perchlorate, with the fuel to provide a propellant with suitable mechanical properties are, it is believed, quite appreciable. It seems also that there may be some problems to overcome from the safety aspect, since the components of high-energy propellants tend to be highly reactive and shock-sensitive. (It is possible that these problems have already been solved—only very limited information is currently available.)

Nevertheless, an impartial opinion suggests that the use of a high-energy boron-hydrocarbon fuel may increase the performance of a solid propellant by, say, 10 to 15 per cent., to a value approaching that of the liquid-oxygen/kerosine propellant combination; and with well-designed rocket motor bodies and low combustion pressures, anything that could be done by a " Lox "/kerosine system could be done by a solid propellant of the type considered. It is not likely to be cheaper, because although much of the complicated machinery necessary in a liquid-fuel rocket is eliminated, the fuel itself can be expected to be very costly.

The new fuel is being developed by the Callery Chemical Company, Callery, Pennsylvania, an organisation that has pioneered the development of boron compounds over the past 10 years, not only as " exotic " fuels, but also for diverse industrial applications such as a metal-fire extinguisher, a welding flux, polymerisation catalysts, fuel additives and fungicides.

OXYGEN BY THE 100 TONS

As a result of certain technological changes in the consuming industries and owing to the perfection of means for the production of inexpensive' oxygen in quantity, an unprecedented growth in the consumption of this gas has taken place in the United States during the past decade. New developments in the oxygen industry have resulted in the erection of modern plants for the production of high-purity oxygen by the air-separation process. These plants are situated adjacent to centres of consumption and supplies of gaseous oxygen are made available to users through pipelines. In a paper presented at a joint symposium on " Recent Developments in Industrial Low-Temperature Gas Separation," organised by the Physical Society and the Institution of Chemical Engineers, and held in London recently, Mr. M. A. Dubs, of the Linde Company, Division of the Union Carbide Corporation, New York, stated that the size of these oxygen-producing plants might range from one supplying a few million cub. ft. of oxygen a month to an installation capable of producing more than 500 tons of the gas in a day.

In air-separation plants the oxygen and its by-products were removed in low-temperature separation equipment. Thus, in a typical plant, the air was compressed to 75 lb. per sq. in. gauge pressure in a centrifugal air compressor and delivered at the ambient temperature to a separation unit. The air was cooled almost to saturation temperature and cleaned in embedded-coil regenerators. The main air stream after leaving the regenerators was treated to remove residual contaminating gases such as carbon dioxide, acetylene and other hydrocarbons. The clean air stream entered the high-pressure column of a double-column cycle where it was separated into an oxygen-rich liquid-air fraction and a liquid-nitrogen fraction. Finally, the purified oxygen was compressed to pipeline pressure by a suitable base-load oxygen compressor and during periods of low demand a booster-compressor pumped the oxygen into storage receivers. When the demand from the user rose above the plant's production capacity, oxygen was withdrawn from the receivers through a pressure-reducing valve.

When peak loads were either very high or absolute continuity of supply must be maintained, liquid-oxygen storage and vaporising equipment had also to be provided. The source of the liquid oxygen could be either a liquid fraction from the gas interchanger, or a separate liquid-oxygen plant. The integration of the oxygen production plant with the liquid supply system, the author pointed out, also permitted the user to increase greatly his oxygen requirements with little prior warning.

INTRODUCTION TO COPPER

The total quantity of copper smelted from its ores has been increasing throughout the present century and now amounts to more than 3½ million tons annually. In a few years' time, it is expected to reach 4 million tons per annum. In addition, as the metal is virtually indestructible, a great deal of scrap copper is remelted and refined afresh, and thus " secondary " copper, in some countries, amounts to more than one-quarter of the total consumption. Great Britain alone uses about 400,000 tons of new copper every year, by far the larger portion coming from within the Commonwealth, in Northern Rhodesia and Canada. The United States, the world's chief user and producer of the metal, consumes, on an average, about one million tons of new copper every year.

These facts are quoted from a new publication of the Copper Development Association, 55 South Audley-street, London, W.1. It is entitled *Introduction to Copper* and relates in clear and simple language where copper is found, how it is extracted from its ores and fabricated, and the various uses to which the metal and its more important alloys are put. The booklet, which contains 56 pages, is particularly well illustrated and should prove useful as a teaching aid in schools as well as acceptable to engineers and general readers. Like other publications of the Association it is issued gratis on request.

The Human Element

Theory and Practice Get Together

Two recent papers on technical training, although quite separate in approach, have an interesting major point in common—the need for industry and the universities to get closer together. The first paper is by Professor G. H. Chambers, called " University Education in Marine Engineering." The second is by Mr. A. W. S. Schumann, an associate member of the Institute of Mining and Metallurgy, called " The Training of Mining Engineers."

Professor Chambers sets out to show that the universities can be of unique value to the marine engineering profession. He is much concerned to get the right kind of co-operation between industry, the sea (meaning the shipping companies and practical experience) and the universities, for the good of the profession. Mr. Schumann is an advocate of a broad education for engineers, for having the trainee broadly based and developed to enable him to think independently. He would have this achieved by broadening the university curriculum for the undergraduate who would return later for a course of more specialised training at his company's expense when he had some practical background from which special training could benefit. The view that a technical graduate is basically a man with an intellectual discipline rather than a body of knowledge is gradually finding increasing support. It is after all not a new idea. It was accepted doctrine in the Eighteenth Century when it was not assumed that the contribution a man could make to a technical problem, be it theoretical or applied, was related to the degree of his specialisation or the narrowness of his field of interests.

Better Safe than Sorry

More people with specialised knowledge are needed to staff the health and safety organisation of the United Kingdom Atomic Energy Authority. There is also an urgent need for education in radiological problems over a wide field of industry and the public service. These were the main conclusions of the committee set up under Sir Alexander Fleck to review the organisations for the control of health and safety within the Authority following the Windscale accident. Their report, which was published as a White Paper last week, makes many recommendations which in themselves constitute a severe implied criticism of existing arrangements.

The Government are criticised for not paying sufficient attention to the problems involved and the committee found " an urgent need to clarify the relations between the main Government departments concerned with health and safety in the atomic energy field, and to strengthen co-ordination between them." The building-up by the Authority of specialised medical staff and the establishment of a national training centre for health, physics and nuclear safety staff under the general supervision of the Research Group (Harwell), and with courses graduated to suit all levels, are recommended.

Another is that Government departments ensure that training in radiological problems is given in the public services and industries for which they are responsible. This is a document of considerable importance which industry, as well as Government, would do well to study completely.

Builders Bewildered

Nearly 3 per cent. of the country's building labour force are unemployed, nearly one-quarter more than a year ago. Moreover, as union leaders point out, many thousands of workers, including craftsmen, have drifted into other employment. The situation is expected to get much worse during the next few months, when unemployment is expected to reach 100,000. The unions are apprehensive lest the slowing down of local authority work, affected by the credit squeeze, gets out of hand, and they view with concern Government departments' insistence on fixed-price tendering—a lead which local authorities are expected to follow.

This is the background against which the building unions' wage claim went forward last week, for a 41 hour week and 8*d.* an hour pay increase. The pay claim is in addition to the 1*d.* an hour to which employers are committed under the cost-of-living sliding-scale agreement. The rejection of this claim, almost inevitable under the present circumstances, is likely to be hotly contested. The threat of unemployment has led the unions to close their ranks and has strengthened the position and influence of communists in the leadership. Already, workers are being advised to cut overtime if redundancy occurs and to press for the sharing out of available work. It will be a pity if a fall in building activity, which is likely to be only of short duration, spoils a situation which in the past few years has been remarkably peaceful and has been accompanied by a marked improvement in productivity.

Price Council Boycott

Some of the leaders of the Trades Union Congress spent three hours last week in informal discussion with Lord Cohen and his two colleagues on the Council on Prices, Productivity and Incomes. Three notable absentees were Mr. Frank Cousins, Mr. W. J. Carron and Mr. Robert Willis, who had consistently opposed accepting the invitation to meet Lord Cohen. Mr. Alan Birch, leader of the T.U.C's seven representatives, made clear in a subsequent statement that the talks did not commit the T.U.C. to any conclusions the Council might draw in their forthcoming report.

The unions' opposition to the economic measures employed by the Government was underlined, doubtless in the hope that Mr. Thorneycroft's departure might lead to a change. Yet Mr. Birch's statement that the unions could not be expected to exercise restraint in wage demands unless other sections of the community were also called on to do the same implied a recognition of the need for restraint. The discussion on the cause and effects of inflation is likely to have been most informative. Union leaders are past masters in the valuable art of compromise but on one issue, that of collective bargaining, they are unlikely to yield an inch. The fact that the delegation opposed " any suggestion for dealing with wages in isolation from other factors involved " indicated that the Council may be thinking of a national wages policy. The fear of being manoeuvred into such a step may well have been the reason for the absence of the tough trio named above.

Selling Space on the Buses

Last week Sir John Elliot, the chairman of the London Transport Executive, appealed to London bus workers to help attract the public back on the buses. For every 100 people carried on London's buses in 1950 there are now only 84. So Sir John has enlisted the aid of 87,000 salesmen and women.

It is an imaginative move if faintly quixotic. It is probable that if the London bus conductors could establish the same reputation for courtesy (it is already good by most standards) as the drivers do for equanimity and good manners the system might get back some of its traffic. It is not likely to win over the entire lost 16 per cent., however. Traffic jams, alternative transport, higher fares and a more widely scattered population are all working against the L.T.E. It cannot yet be proved, but a lower density of private cars in the centre would probably be the major favourable development. Public transport systems throughout the world are contracting as the car and moped reach lower income brackets.

Meanwhile, the trend of traffic may be helping the bus union representatives to attain a cautious mood. There is a flavour of poetic justice in the idea of the bus workers helping to sell the service from which they want a higher return.

Fare Stage

The rejection for the second time by London Transport Executive of the claim by their 53,000 bus employees for a 25*s.* wage increase (without making a counter-offer) has resulted in complete deadlock between the Executive and the Transport and General Workers' Union. A meeting last week, attended by three delegates from each side with Sir Wilfred Neden in the chair, could not agree on further talks to work out a solution, nor could they agree on taking the claim to arbitration.

The L.T.E. made it plain that they would yield nothing and saw, therefore, little point in continued argument. The union pointed out that their delegate conference had already decided against arbitration and that they were most unlikely to reverse their decision. Both sides will now consider Sir Wilfred Neden's proposals for mediation by a third party. The union's opposition to arbitration reflects the deep distrust in this procedure which was created by Government statements last October. The threat of redundancy has now made the position even more delicate. The fact that the L.T.E. have decided to reduce their mileage schedules by about 4 per cent. from next summer due to falling passenger traffic is likely to shift the emphasis in the union's attitude from higher wage rates to a shorter working week and less overtime. During the first half of 1957 the L.T.E. carried 360,000 less bus passengers a day than in the first half of 1956—it suggests that the public's resistance to continually increasing fares is strengthening. Higher labour costs may well accentuate this trend and cut deeply into the number employed.

Taxation and Corruption

The story which achieved much publicity last week about a father disowning his son legally so that he could get a scholarship is unique of its kind perhaps. It is, however, only one more example of the corrupting effect of high taxation.

The dangers inherent in this situation are obscured because the two main political parties split cleanly on this issue and therefore to plead for lower taxation can always be represented as an attack on social progress. It can also be easily said that those who object to higher taxation are fighting the redistribution of the national income and when there are votes to be sought this can always be dressed up to look like acute social selfishness.

It is therefore worth recalling a recent case which can be put alongside the case of legal disownment. When a woman recently won a huge capital gain for the stake of a few pence she became for a day or two a public figure and the object of good-natured envy of a large section of the voting population. With the odds many millions to one against her she became a rich woman in a fantastic speculation—and the British public said good luck to her. The truth is we all want capital gains because we are heavily penalised for working. Money that is earned is small beer, literally too, and we are all bloated speculators. Here is a side of the redistribution of income which has still to be thought out by honest men of all political views.

Atomic Review

European Start-Up

NOTHING involving people or nations is ever simple, and the formulation of workable agreements between the countries of Europe is a task calling for great ingenuity and goodwill. Yet in the atomic energy field, at least, progress is being made, and both European organisations concerned with large-scale nuclear co-operation are approaching the time when discussion will give place to action. The nature and aims of O.E.E.C. and Euratom have been dealt with in some detail in earlier articles in ENGINEERING, together with other international nuclear organisations; in particular the relationships of the various bodies were discussed in vol. 181, page 397, and in vol. 182, page 475, 1956. A list of references to articles on this subject is given below. The following notes bring these articles up to date.

European Nuclear Energy Agency

The Council of the O.E.E.C. (Organisation for European Economic Co-operation) adopted on December 20 the statute of the European Nuclear Energy Agency and signed a convention on security control. At the same time twelve member countries of the Organisation signed the international agreement setting up a first joint undertaking, the European Company for the Chemical Processing of Irradiated Fuel (Eurochemic). These decisions are the outcome of the work done in the course of the year by the Steering Committee for Nuclear Energy under the chairmanship of Professor Nicolaidis.

The European Nuclear Energy Agency will be a specialised agency established as from February 1, 1958, within the framework of the O.E.E.C. and under the authority of its Council. The objective of the Agency is to further the development of the production and uses of nuclear energy for peaceful purposes through technical co-operation among the countries of Western Europe. Its functions will be to promote the establishment of joint undertakings between those countries, discuss their research and production programmes for nuclear energy, study their requirements for raw materials and capital equipment, promote the liberalisation of trade in these products, develop facilities for the training of specialists and help to finalise and harmonise national legislation, in particular as regards the safeguarding of public health, prevention of accidents, third-party liability and atomic risk assurance. When carrying out these tasks, the Agency will take into account the work done by the other international organisations concerned and will, as far as possible, call on them for assistance. It is provided in particular that in view of the special powers attributed by the six countries to Euratom, the Agency will conclude an arrangement with the European Commission as soon as possible, in order to establish close co-operation with Euratom.

The exclusively peaceful character of the Agency's objectives is ensured by a security control guaranteeing that the operation of the joint undertaking, together with the materials, equipment or services provided by the Agency, cannot be used for military purposes. The basic rules of this security control are laid down in a special convention and very closely follow those defined in the statute of the International Atomic Energy Agency and the Euratom Treaty. They provide an examination of the plant subject to control; a system of quantitative control for nuclear fuel; on-the-spot supervision by international inspectors and, in cases of non-observance, the possibility of imposing penalties by a majority vote. Provision is made for an international tribunal to settle certain disputes to which the exercise of the control may give rise. As the Euratom countries have established a complete system of security control, it is specified that control on Euratom territory will be exercised by its bodies under conditions to be settled by an agreement between the Agency and Euratom. Provision is also made for co-operation with the International Atomic Energy Agency in regard to control.

Eurochemic

At the same time as these general decisions were adopted by the Council, twelve member countries of the Organisation reached an agreement to set up a first joint undertaking, the Eurochemic Company. The purpose of this company will be to build and operate a plant for the chemical treatment of irradiated fuel (that is, a plant for the production of plutonium) which will be erected at the Nuclear Research Centre at Mol (Belgium). This plant will have a capacity for treating approximately 100 tons of natural or slightly enriched uranium per year. It is expected to cost 12 million E.P.U. units of account and will probably be in operation in 1961. This undertaking is constituted as a European company which has been set up under an international convention with the participation of governments, public institutions and semi-public or private undertakings. Certain governments have stated their intention of transferring their initial participation to private industry. A start will be made on the preparatory work at Mol for the erection of the plant on the signing of the convention without waiting for its ratification.

Capital for Eurochemic

The authorised capital of the company shall be 20 million European Payments Union units of account (£7·14 million). An E.P.U. unit is defined as "0·88867088 gm. of fine gold," and is effectively equal to one dollar. The capital is to be divided into 400 shares, each of the nominal value of 50,000 units of account, all of which shall be initially subscribed and allotted as follows:

The Government of the Federal Republic of Germany	68	shares	3,400,000
The Government of the Republic of Austria	20	,,	1,000,000
The Government of the Kingdom of Belgium	44	,,	2,200,000
The Government of the Kingdom of Denmark	22	,,	1,100,000
Le Commissariat à l'Energie Atomique in Paris	68	,,	3,400,000
Il Comitato Nazionale per le Richerche Nucleari in Rome	44	,,	2,200,000
The Government of the Kingdom of Norway	20	,,	1,000,000
The Government of the Kingdom of the Netherlands	30	,,	1,500,000
La Junta de Energia Nuclear in Lisbon	6	,,	300,000
Aktiebolaget Atomenergi in Stockholm	32	,,	1,600,000
The Government of the Swiss Confederation	30	,,	1,500,000
The Government of the Turkish Republic	16	,,	800,000

BWR and HAR and Heavy Water

Work is in progress to set up two other European establishments. A project is under discussion for the joint operation of the boiling-water reactor built at Halden (Norway) by the Norwegian Institute for Atomic Energy. Secondly, the establishment of a homogeneous aqueous reactor at the British Research Centre at Winfrith Heath is also under study; the fuel will circulate through the reactor in the form of a solution. The Steering Committee also agreed at its last session to study the possibilities and the economic conditions for the production of heavy water in Iceland by using geothermal energy which provides an abundant source of heat at low cost. A similar project in New Zealand, however, was abandoned. Proposals will also shortly be submitted to the Council for the liberalisation of inter-European trade in products relating to nuclear energy. This question is being studied as part of the general discussions on the Free Trade Area. Finally, the work on training, rules for the safeguarding of health and liability and insurance in connection with atomic risk will be continued by the Agency. One of the Agency's first objectives will be to work out joint rules covering third-party liability of operators of nuclear plant.

Euratom

Euratom was formally established on January 1. On January 7, the Council of foreign ministers of the six nations, France, Belgium, Luxembourg, the Netherlands, Italy and Germany, made their joint nominations for the five members of the Commission of Euratom. M. Louis Armand (France) has been appointed president, and Signor E. Medi (Italy) vice-president. The other three members are Mr. P. de Groote (Belgium), Herr H. Krekeler (Germany) and Mr. E. Sassen (the Netherlands). M. Armand and Herr W. Hallstein, president of the European Common Market Commission, are to choose a permanent capital site for the European Coal and Steel Community (E.C.S.C.), the European Common Market and Euratom by June 1, but a temporary headquarters, probably in Luxembourg or Val Duchesse near Brussels, will probably be selected within a few days. So far, however, no projects have been decided, though a Community Nuclear Research Centre is planned, which will be responsible for standardising nuclear terminology and measurements, and for ensuring the execution of research programmes.

Community Energy Needs

Unless nuclear energy is developed as a source of power, the energy imports of the six Community countries will have to be more than tripled by 1975, and will cost more than 4,600 million dols. a year. This is the main conclusion of the report just published by a joint committee of the European Coal and Steel Community's High Authority and Council of Ministers, which surveys the structure and tendencies of the energy situation in the Community countries. This is the first time that a survey of this kind, based on uniform methods, has been made for the six countries. Its aim is to give a complete and detailed picture of existing sources of energy, and to forecast future needs of the different forms of energy and ways of meeting them.

CERN President

At its ninth session in Geneva on December 19, 1957, the Council of CERN, the European Organisation for Nuclear Research, elected M. François de Rose of France as its president for 1958. In compliance with the terms of the convention, which limits tenure of office to three successive years, M. de Rose succeeds Sir Ben Lockspeiser, who has presided over the governing body of CERN since October, 1954. Mr. J. Willems of Belgium and Professor W. Heisenberg of Germany have been elected Vice-Presidents. They succeed M. de Rose and Professor Holtsmark of Norway. Professor E. Amaldi of Italy assumed the chairmanship of the Scientific Policy Committee, succeeding Professor Heisenberg. Chairmanship of the Finance Committee was taken over by Mr. J. H. Bannier of the Netherlands in succession to Mr. Willems of Belgium. The Council approved total contributions from the member states for 1958 of 56 million Swiss Francs. At the same time the Council agreed that the contributions for the two years 1958 and 1959 should be fixed at a ceiling of 100 million Swiss Francs. During 1957 the entire staff of CERN moved into its permanent headquarters at Meyrin near Geneva. The total number of personnel is now 598 of which about two-thirds are scientific and technical.

CERN Accelerators

While 1957 was the year of peak building activity, 1958 will see the beginning of a nuclear research programme with the first of CERN's two big accelerators, the 600 MeV synchro-cyclotron. A long-term programme of research will be carried out. Assembly of the accelerator components in the recently completed buildings of the 25 GeV proton synchrotron—known as the "Eurotron"—will start early next year. The proton synchrotron is expected to come into

operation in 1960. Experimental physicists, in collaboration with CERN's theoretical division, have started preliminary work on the preparation of a suitable research programme. A special section comprising both experimental and theoretical physicists has recently been set up to investigate new principles of high energy particle acceleration.

Conference on High Energy Physics

CERN will again be host to nuclear physicists of all nations in 1958, when the Eighth Annual Conference on High Energy Nuclear Physics will be held in Geneva as a continuation of the well-known international conferences held for seven years in succession at the University of Rochester in the United States. Invitation to the CERN Conference will shortly be sent out to physicists of CERN member states and others, including the United States and the U.S.S.R.

References to International Co-operation

Previous references in ENGINEERING to international nuclear co-operation are as follows: vol. 178, page 196, 1954; vol. 179, pages 618 and 769; vol. 180, page 3, 1955; vol. 181, pages 245, 397, 506, 542 and 575; vol. 182, page 475, 1956; vol. 183, pages 251, 287 and 382; vol. 184, pages 157, 284, 348, 475 and 763, 1957; and vol. 185, page 43.

Reactors

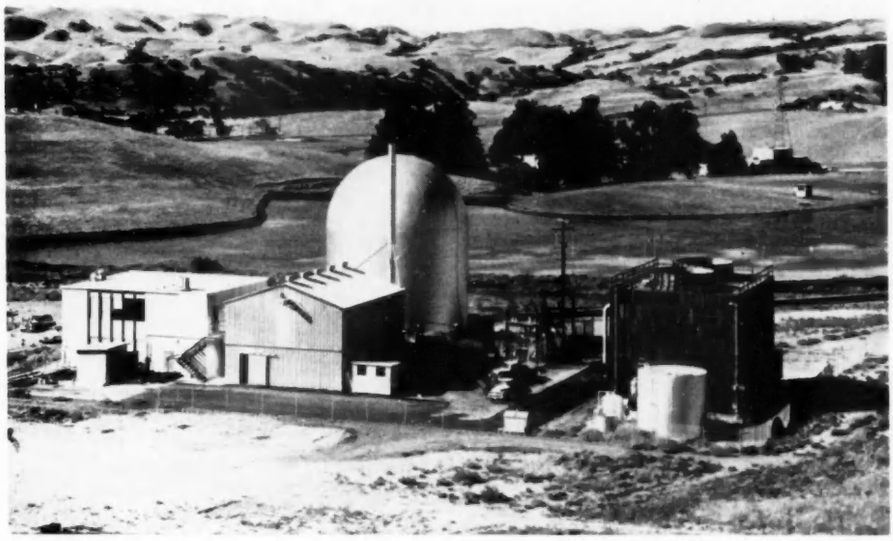
U.S. Heavy-Water Gas-Cooled Project

Mr. Lewis L. Strauss, Chairman of the U.S. Atomic Energy Commission, has announced that a proposal for a nuclear power plant of advanced design has been filed with the Commission by the East Central Nuclear Group and the newly formed Florida West Coast Nuclear Group. The proposal is the second received this month in response to the invitation issued by the Commission in January, 1957, under its Power Demonstration Reactor Program. The first was the proposal of the Pennsylvania Power and Light Company and Westinghouse Electric Corporation for a large-scale homogeneous nuclear power plant. The East Central-Florida West Coast Group proposal includes the design, development, construction and operation of a high-temperature, gas-cooled, heavy water-moderated, pressure-tube reactor of 50 MW (electrical) capacity. The plant would be built on the system of the Florida West Coast Group and would be designed as the prototype for a later 200 MW plant. The smaller prototype plant would utilise slightly enriched uranium fuel, but it is expected that a similar plant of 200 MW could operate on natural uranium fuel.

The new proposal replaces one made on April 30, 1957, by the Florida Nuclear Power Group. The Commission determined that the earlier proposal was not acceptable as a basis for negotiation of a contract under provisions of the Power Demonstration Reactor Program. The April proposal was for a heavy-water-moderated, gas-cooled reactor fuelled with natural uranium, and having a net electrical capacity of 136 MW. Under the proposal the Commission and the companies would share equally the costs of research and development and the Florida West Coast Group on whose system the plant would be built would finance plant construction costs and would operate the plant. The estimated completion date for the plant is some time between June 30, 1962, and June 30, 1963. The companies expressed the belief that the June 30, 1963, date is more realistic. The proposal states that it is expected that the General Nuclear Engineering Corporation of Dunedin, Florida, will be the nuclear design agent and nuclear project engineer and that the American Gas and Electric Service Corporation will be principal design and construction engineer for the project.

Boiling Water Reactor at Vallecitos

The General Electric Company—Pacific Gas and Electric Company 5 MW nuclear power plant, said to be the first in the world to supply power on the basis of exclusively private financing, has recently been dedicated. The accompanying illustration shows the domed cylinder which houses the General Electric boiling-water reactor, and in front the Pacific Gas and Electric turbine-generating plant. The control building is on the left and the tower for the cooling condenser water is on the right. Power is fed into the Pacific Gas and Electric transmission system for Northern and Central California. The reactor is a facility of General Electric's Vallecitos Atomic Laboratory in Alameda County, California. It was built primarily for development work on the 180 MW Dresden nuclear power plant, which General Electric is building near Chicago for the Commonwealth Edison Company and the Nuclear Power Group Incorporated. In the background on the right of the illustration is the laboratory's experimental physics facility. The building on the left of it is radioactive materials facility. Details of another American boiling-water reactor, the Argonne National Laboratory's EBWR, were given in Atomic Review on February 1, 1957.



The 5 MW boiling water reactor power plant built by the General Electric and Pacific Gas and Electric companies is said to be the first to supply power on the basis of all-private financing.

General Electric Pool Reactor for Spain

Successful tests of a reactor built by the General Electric Company for erection in the Moncloa area near Madrid have recently been completed at the company's Vallecitos Laboratory. The 3 MW (thermal) open pool reactor is to be assembled in Spain early next year and is expected to become critical in March. Designed and built by the G.E. Atomic Power Equipment Department of San Jose, California, the reactor will be used for physics and medical research and for training personnel in reactor operation. It will be Spain's first reactor. General Electric expect to deliver two similar reactors to Latin America during 1958.

Nuclear Test Reactor for Vallecitos

The United States Atomic Energy Commission has filed notice of proposed issuance of a permit to General Electric Company for construction of a research reactor at its Vallecitos Atomic Laboratory in the Pleasanton-Livermore area of California. The proposed reactor is a 30 MW (thermal) facility, cooled and moderated by pressurised light-water, and using graphite as a reflector. To be known as the Nuclear Test Reactor (NTR), the facility will be used principally to measure absorption of neutrons in small samples of structural materials and neutron multiplication in fuel samples, to provide neutrons for calibrating foils to be used in critical experiments, and to provide a high neutron flux for experimental studies. The company expects to complete the reactor, on which an inquiry is to be held, between June, 1958 and January, 1959.

General Notes

Burst Slug Detection

Accles and Pollock Limited of Oldbury, Birmingham, are supplying prefabricated assemblies for the burst-slug-detection installation in the nuclear power station being built by the General Electric Company Limited and Simon-Carves at Hunterston, Ayrshire. Normal practice has been to build up the installations from straight tube on site. Prefabrication, it is claimed, will not only save time and money on site, but by using the existing facilities of the Accles and Pollock factory will also simplify quality control. There should also be an obvious saving in the amount of plant needed on site. The complete assemblies will include over 40 miles of stainless-steel tube, manipulated to the required shapes, welded, and fitted with special couplings.

Cermets

The patent referred to in a discussion of cermets in Atomic Review last week was United Kingdom application No. 27838/56, and the inventors were D. T. Livey and P. Murray.

Lord Citrine Joins U.K.A.E.A.

Lord Citrine has been appointed by the Prime Minister as a part-time member of the United Kingdom Atomic Energy Authority in succession to Sir Luke Fawcett.

Directors to Study Radioactive Isotopes

A three and a half day course will be run at Harwell next April 14 in conjunction with the United Kingdom Atomic Energy Authority, expressly designed for members of the Institute of Directors. It will offer directors a unique opportunity of obtaining a practical general knowledge of what radioactive isotopes can do for industry. Experience in Britain and particularly America during the past few years has shown that great economies can be effected in industry through the use of radioactive isotopes. The all-inclusive fee for accommodation, transport, lectures and meals, is £40. Applicants should write to: the Deputy Director-General, Institute of Directors, 10 Belgrave-square, S.W.1.

NOTICES OF MEETINGS

Association of Engineering Distributors

LONDON
Council Luncheon and Council Meeting. Howard Hotel, Norfolk-street, W.C.2. Tues., Jan. 21, 12.30 p.m. (Both functions open to all members of the Association.)

Association of Supervising Electrical Engineers

CROYDON
"Radar Aids to Navigation," by N. E. R. Vaus. South London Branch. Greyhound Hotel, High-street, Croydon. Thurs., Jan. 23, 8 p.m.

British Computer Society

LONDON
"Physical Principles of Xerography," by Dr. N. Levin. Caxton Hall, off Victoria-street, S.W.1. Mon., Jan. 20, 6.15 p.m.

British Institution of Radio Engineers

CARDIFF
"Applications of Magnetic Recording," by J. Cunningham-Sands. South Wales Section. Department of Physics, University College of South Wales, Cardiff. Wed., Jan. 22, 6.30 p.m.

Building Centre

LONDON
Films on "The Control of Chimney Draught," exhibited by Omnia Constructions Ltd. Wed., Jan. 22, 12.45 p.m.

Chemical Society

ABERDEEN
"New Chemical Instruments Developed at Harwell," by Dr. R. Spence. Aberdeen Branch. Marischal College, Aberdeen. Thurs., Jan. 23, 7.30 p.m.
LEEDS
"Needles in Geochemical Haystacks," by A. A. Smales. Leeds Branch. Chemistry Lecture Theatre, The University, Leeds. Mon., Jan. 20, 6.30 p.m.

Electrical Association for Women

LONDON
"Living Electrically in Austria and Northern Italy," by Miss M. P. Binks. Institution of Electrical Engineers, Savoy-place, W.C.2. Mon., Jan. 20, 6 p.m.

Engineers' Guild

BRISTOL
Luncheon Meeting. Western Branch. The Berkeley, Clifton, Bristol. Thurs., Jan. 23, 1 p.m.

Illuminating Engineering Society

BRISTOL
Discussion on "Lighting for Television Studios." Bath and Bristol Centre. Royal Hotel, Bristol. Mon., Jan. 20, 7 p.m.

Incorporated Plant Engineers

LONDON
"History and Development of the Single-Bucket Excavator," by A. Broughton. College of Preceptors, Bloomsbury-square, W.C.1. Thurs., Jan. 23, 7 p.m.*

Institute of Fuel

LONDON
"Shatter Strength of Cokes from High-Volatile Coals," by Dr. D. W. Gillings and W. Lawson. Institution of Civil Engineers, Great George-street, S.W.1. Wed., Jan. 22, 5.30 p.m.*
BIRMINGHAM
"Mechanical Properties of Coal," by Dr. L. C. Tyte. Midland Section. James Watt Memorial Institute, Great Charles-street, Birmingham. Thurs., Jan. 23, 6.30 p.m.
GLASGOW
"Fuel Aspects of Nuclear Power Generation," by J. A. Croucher. Scottish Section. Royal College of Science and Technology, Glasgow. Thurs., Jan. 23, 7 p.m.

Institute of Marine Engineers

LONDON
"Diesel Hydraulic Propulsion," by F. J. Mayor. Junior Lecture. Borough Polytechnic, Borough-road, S.E.1. Wed., Jan. 22, 7 p.m.

Institute of Metals

BIRMINGHAM
"Electric Furnace Developments," by P. F. Hancock. Birmingham Local Section. Birmingham Exchange and Engineering Centre, Stephenson-place, Birmingham. Thurs., Jan. 23, 6.30 p.m.

Institute of Physics

LONDON
"Presenting Science in Physics Text-Books," by B. C. Brookes. Education Group. Wed., Jan. 22, 6 p.m.*
BIRMINGHAM
"The Computer and Its Uses," by C. Robinson. Midland Branch. Birmingham Exchange and Engineering Centre, Stephenson-place, Birmingham 2. Tues., Jan. 21, 7 p.m.

Institute of Road Transport Engineers

DURHAM
"Design and Construction of a Modern Goods-Carrying Vehicle," by A. S. C. Marks. North Eastern Centre. Three Tuns Hotel, Durham City. Tues., Jan. 21, 7 p.m.

Institution of Chemical Engineers

CHESTER
"Production of Boron 10 by Distillation of Boron Trifluoride," by P. Netley. North Western Branch. Blossoms Hotel, Chester. Tues., Jan. 21, 7 p.m.
LEEDS
"Heat Transfer Analogues," by N. L. Franklin, G. T. Matthews and J. E. Cook. North Western Branch. Chemistry Department, The University, Leeds. Wed., Jan. 22, 7 p.m.

Institution of Civil Engineers

LONDON
"Design and Construction of the Foundations and Pressure Shell of the 8 ft. by 8 ft. High-Speed Wind Tunnel of the R.A.E., Bedford," by J. F. Greinig, R. W. Horseman and A. N. Kinkead. Tues., Jan. 21, 5.30 p.m.*
EDINBURGH
"Scale Models in Hydraulic Engineering," by Professor Jack Allen. Edinburgh and East of Scotland Association. North British Hotel, Edinburgh. Wed., Jan. 22, 6 p.m.

Institution of Electrical Engineers

LONDON
"Effect of Modern Industrial Requirements on Electrical Instrument Design," by Dr. G. F. Tagg. Measurement and Control Section. Tues., Jan. 21, 5.30 p.m.*
"Special Problems of Broadcasting in Sweden," by E. Esping. Radio and Telecommunication Section. Wed., Jan. 22, 5.30 p.m.*
BOURNEMOUTH
"Electricity in Modern Commercial Horticulture," by C. A. Cameron Brown and A. W. Gray. Southern Centre. Grand Hotel, Bournemouth. Wed., Jan. 22, 6.30 p.m.
CARLISLE
"Cathodic Protection," by L. B. Hobgen, K. A. Spencer and P. W. Heselgrave. North Eastern Centre. Carlisle Technical College, Carlisle. Fri., Jan. 24, 7 p.m.
EDINBURGH
"Some Aspects of Half-Wave Magnetic Amplifiers," by G. M. Ettinger; and "Some Transistor Input Stages for High-Gain D.C. Amplifiers," by Dr. G. B. B. Chaplin and A. R. Owens. Scottish Centre. Carlton Hotel, North Bridge, Edinburgh. Mon., Jan. 20, 7 p.m.
GLASGOW
"Some Aspects of Half-Wave Magnetic Amplifiers," by G. Ettinger; and "Some Transistor Input Stages for High-Gain D.C. Amplifiers," by Dr. G. B. B. Chaplin and A. R. Owens. Scottish Centre. Royal College of Science and Technology, George-street, Glasgow, C.1. Tues., Jan. 21, 7 p.m.
LEEDS
"Electricity in Modern Commercial Horticulture," by C. A. Cameron Brown and A. W. Gray. North Midland Centre. Offices of the Yorkshire Electricity Board, 1 Whitehall-road, Leeds. Tues., Jan. 21, 6.30 p.m.

Institution of Engineers and Shipbuilders in Scotland

GREENOCK
"Craneage in Works and Shipyards," by D. L. Nicolson. Joint Meeting with Greenock Association of Engineers. The Lorne, Greenock. Tues., Jan. 21, 7.30 p.m.

Institution of Heating and Ventilating Engineers

LIVERPOOL
Discussion on "Ventilation and Packaged Air Conditioners." Liverpool Branch. College of Building, Clarence-street, Liverpool. Tues., Jan. 21, 6.30 p.m.

Institution of Locomotive Engineers

LONDON
"A New Method of Assessing the Riding of Vehicles and Some Results Obtained," by J. C. Loach. Institution of Mechanical Engineers, 1 Birdcage-walk, St. James's Park, S.W.1. Thurs., Jan. 23, 5.30 p.m.*

Institution of Mechanical Engineers

LONDON
Discussion on "The Measurement of Noise and Vibration." Applied Mechanics Group. Wed., Jan. 22, 6.45 p.m.*
"Management Control of Small Engineering Firms," by L. Fontaine, W. R. Spencer and J. W. Walker. Meeting in conjunction with the Industrial Administration and Engineering Production Group. Fri., Jan. 24, 4.30 p.m.
CARDIFF
Thomas Hawksley Lecture: "Some Engineering Problems in Connection with the Industrial Application of Nuclear Energy," by Sir Claude Gibb. South Wales Branch. South Wales Institute of Engineers, Park-place, Cardiff. Tues., Jan. 21, 6 p.m.
NOTTINGHAM
"Some Aspects of Heat Pump Operation in Great Britain, with Particular Reference to the Shinfield Installation," by Miss Miriam V. Griffiths. East Midlands Branch. College of Art and Crafts, Waverley-street, Nottingham. Tues., Jan. 21, 6.30 p.m.

Institution of Production Engineers

CARDIFF
"The New Industrial Pattern of South Wales," by A. J. Nicholas. Cardiff Section. South Wales Institute of Engineers, Park-place, Cardiff. Fri., Jan. 24, 7 p.m.
COVENTRY
"Impact Extrusion and Cold-Flow Pressing of Ferrous and Non-Ferrous Metals," by H. Byles. Coventry Section. Craven Arms, High-street, Coventry. Mon., Jan. 20, 7.15 p.m.
DARLINGTON
"Nuclear Power and Its Effect on the Production Engineer," by I. Munro. Tees side Section. College of Further Education, Cleveland-avenue, Darlington. Tues., Jan. 21, 7 p.m.
DERBY
"We Build the Jig Mill," by S. C. Fenton. Derby Section. College of Art, Derby. Fri., Jan. 24, 7 p.m.
NEWCASTLE-UPON-TYNE
"Spark Machining," by E. A. Sweetman. Newcastle Section. Neville Hall, Westgate-road, Newcastle-upon-Tyne. Mon., Jan. 20, 7 p.m.

Institution of the Rubber Industry

MELKSHAM
"Extruders and Extruding," by A. Crowther. Melksham House, Melksham. Wed., Jan. 22, 7.45 p.m.

Institution of Structural Engineers

LONDON
"The Work of the European Committee on Concrete," by Professor A. L. L. Baker. Thurs., Jan. 23, 6 p.m.*
BIRMINGHAM
"Steelwork in Transit Shed 102, Southampton Docks," by F. M. Bowen and B. E. S. Ranger. Midland Counties Branch. James Watt Memorial Institute, Great Charles-street, Birmingham. Fri., Jan. 24, 6 p.m.
GLASGOW
"Recent Concrete Construction in Scotland," by P. Russell. Scottish Branch. Institution of Engineers and Shipbuilders in Scotland, 39 Elmbank-crescent, Glasgow, C.2. Tues., Jan. 21, 7 p.m.

Junior Institution of Engineers

LONDON
"Axle Counting in Railway Signalling," by H. J. N. Riddle. Fri., Jan. 24, 7 p.m.*

Liverpool Engineering Society

LIVERPOOL
"Alternating-Current Systems for Railway Electrification," by A. D. Gratton. Joint Meeting with the Mersey and North Wales Centre of the Institution of Electrical Engineers. Wed., Jan. 22, 6.30 p.m.

North East Coast Institution of Engineers and Shipbuilders

NEWCASTLE-UPON-TYNE
"Extended Heat Exchange Surface for Boilers," by R. E. Zoller. Mining Institute, Neville Hall, Newcastle-upon-Tyne. Fri., Jan. 24, 6.15 p.m.

Plastics Institute

LONDON
Discussion on "European Free Trade Area," opened by J. H. Pinder. Wellcome Building, 183-193 Euston-road, N.W.1. Tues., Jan. 21, 6.30 p.m.

Reinforced Concrete Association

LONDON
"The Work of the European Committee on Concrete," by Professor A. L. L. Baker. 11 Upper Belgrave-street, S.W.1. Thurs., Jan. 23, 6 p.m.*

Royal Aeronautical Society

LONDON
"Environments and Environmental Testing," by P. J. Duncton and T. F. R. George. Tues., Jan. 21, 7 p.m.
"Guidance and Control," by L. H. Bedford. Thurs., Jan. 23, 7 p.m.

Royal Society of Arts

LONDON
"The Architecture of New Towns," by Frederick Gibberd. Wed., Jan. 22, 2.30 p.m.

Scientific Film Association

LONDON
"Health and Safety in Industry," with films, by J. N. Macdonald. Mezzanine Cinema, Shell-Mex House, Strand, W.C.2. Thurs., Jan. 23, 6.30 p.m.
"The High-Speed Camera in Industry," by John Hadland. Royal Photographic Society, Princes Gate, S.W.7. Fri., Jan. 24, 7 p.m.

Sheffield Metallurgical Association

SHEFFIELD
Annual General Meeting. Presidential Address by R. C. Baker. B.I.S.R.A. Laboratories, Hoyle-street, Sheffield. Tues., Jan. 21, 7 p.m.

Society of Chemical Industry

LONDON
Corrosion Group Conversazione. Exhibits mainly in field of protective coatings. Battersea College of Technology, Battersea Park-road, S.W.11. Thurs., Jan. 23, 6.30 p.m. Exhibits also on view Fri., Jan. 24, 9.30 a.m. to 3.30 p.m. (Tickets to view not required.)

Society of Instrument Technology

CARDIFF
"Use of Computers in Process Control," by W. G. Proctor. South Wales Section. College of Technology, Cardiff. Wed., Jan. 22, 6.45 p.m.

The address and telephone number of the headquarters of each institution are given below. Meetings in the headquarters town are held there unless otherwise stated. Particulars for this column should reach the Editor not later than Monday morning in the week preceding the date of the meeting.

* An asterisk is placed where it is understood that tea is available prior to the time stated.

Association of Engineering Distributors, Hastings House, Norfolk-street, London, W.C.2. (TEMple Bar 4941.)
Association of Supervising Electrical Engineers, 23 Bloomsbury-square, London, W.C.1. (LANgham 5927.)
British Computer Society, 29 Bury-street, St. James's, London, S.W.1.
British Institution of Radio Engineers, 9 Bedford-square, London, W.C.1. (MUSeum 1901.)
Building Centre, 26 Store-street, London, W.C.1. (MUSeum 5400.)
Chemical Society, Burlington House, Piccadilly, London, W.1. (REGent 0675.)
Electrical Association for Women, 25 Foubert's-place, London, W.1. (GERrard 5212.)
Engineers' Guild, 78 Buckingham-gate, London, S.W.1. (ABBey 7315.)
Illuminating Engineering Society, 32 Victoria-street, London, S.W.1. (ABBey 5215.)
Incorporated Plant Engineers, 12 The Parade, Solihull, Warwickshire. (Solihull 1111.)
Institute of Fuel, 18 Devonshire-street, Portland-place, London, W.1. (LANgham 7124.)
Institute of Marine Engineers, Memorial Building, 76 Mark-lane, London, E.C.3. (ROYal 8493.)
Institute of Metals, 17 Belgrave-square, London, S.W.1. (BELgravia 3291.)
Institute of Physics, 47 Belgrave-square, London, S.W.1. (BELgravia 6111.)
Institute of Road Transport Engineers, 69 Victoria-street, London, S.W.1. (ABBey 6248.)
Institution of Chemical Engineers, 16 Belgrave-square, London, S.W.1. (BELgravia 3647.)
Institution of Civil Engineers, Great George-street, London, S.W.1. (WHItehall 4577.)
Institution of Electrical Engineers, Savoy-place, Victoria-embankment, London, W.C.2. (TEMple Bar 7676.)
Institution of Engineers and Shipbuilders in Scotland, 39 Elmbank-crescent, Glasgow, C.2. (Central 5181.)
Institution of Heating and Ventilating Engineers, 49 Cadogan-square, London, S.W.1. (SLOane 3158.)
Institution of Locomotive Engineers, 28 Victoria-street, London, S.W.1. (ABBey 6672.)
Institution of Mechanical Engineers, 1 Birdcage-walk, St. James's Park, London, S.W.1. (WHItehall 7476.)
Institution of Production Engineers, 10 Chesterfield-street, London, W.1. (GROsvenor 5254.)
Institution of the Rubber Industry, 4 Kensington Palace-gardens, London, W.8. (BAYswater 9101.)
Institution of Structural Engineers, 11 Upper Belgrave-street, London, S.W.1. (SLOane 7128.)
Junior Institution of Engineers, Pepys House, 14 Rochester-row, London, S.W.1. (VICtoria 0786.)
Liverpool Engineering Society, 9 The Temple, 24 Dale-street, Liverpool 2. (Central 3717.)
North East Coast Institution of Engineers and Shipbuilders, Bolbec Hall, Newcastle-upon-Tyne 1. (Newcastle 20289.)
Plastics Institute, 6 Manville-place, London, W.1. (WELbeck 5439.)
Reinforced Concrete Association, 94-98 Petty France, London, S.W.1. (ABBey 4504.)
Royal Aeronautical Society, 4 Hamilton-place, London, W.1. (GROsvenor 3515.)
Royal Society of Arts, John Adam-street, Adelphi, London, W.C.2. (TRAfalgar 2366.)
Scientific Film Association, 164 Shaftesbury-avenue, London, W.C.2. (TEMple Bar 4694.)
Sheffield Metallurgical Association, 66 Ringstead-crescent, Sheffield 10. (Sheffield 62144.)
Society of Chemical Industry, 14 Belgrave-square, London, S.W.1. (BELgravia 3681.)
Society of Instrument Technology, 20 Queen Anne-street, London, W.1. (LANgham 4251.)

Companies in the News

Profits in 1957 and Beyond

During 1957 reports received from some 2,750 companies showed that trading profits rose by 5 per cent. compared with 9 per cent. the previous year. Although net dividend payments increased by 6·6 per cent., earnings for equity shareholders fell by 2 per cent. The corresponding figures for manufacturing companies profits increased by only 3 per cent. and earnings fell by 4 per cent. These figures are based upon an analysis by the *Financial Times* of reports received during the Calendar year, which mostly relate to a period from September, 1956, to September, 1957.

In the case of most firms, the fall in earnings was caused by narrower margins, higher depreciation and higher tax payments. The latter resulted from the ending of the investment allowances for most industries and by the increase in the distributed profits tax. The higher depreciation payments were determined by heavy capital expenditure by manufacturers which rose from £694 million in 1955 to £833 million in 1956. The narrowing margins were due mainly to the fact that manufacturing industry was operating below capacity; until May, 1957, industrial production was running below the average level of 1955, and the large investments in additional capacity were therefore largely unused. In addition, wage rates rose by 6 per cent., which could not be absorbed in higher physical output as in former years.

Prospects for 1958 are vitally affected by industry's ability to increase or at least maintain production. In the first article of the series in which the prospects of the engineering industry are reviewed each year (ENGINEERING, January 3, page 19, 1958) further falls in turnover were anticipated. Whatever economies result from lower raw material prices or from the fact that wages are unlikely to rise as much as last year, these are unlikely to compensate for lower volume of output. Sir George Nelson considers that the electrical engineering industry will continue to expand " in spite of growing price difficulties in overseas markets," and sets great store " on our ability to hold down production costs." Sir Patrick Hennessy agrees with Sir George and anticipates continued high output of motor vehicles, with the same proviso. Mr. J. P. Chambers of I.C.I. states that his company's forecasts indicate " steady progress all round both at home and overseas." Esso Petroleum (Sir Leonard Sinclair) view the future with confidence. Lord Chandos's guess—" that the volume of orders which we shall book in 1958 will be somewhat smaller than the huge total reached in 1957, and that the amount of unexecuted orders at the end of 1958 will be smaller than to-day "—will be widely echoed. But these are leading companies with substantial resources. The smaller fish, so important in Britain, are unlikely to fare so well. For them profits will be harder to earn and somewhat less than last year.

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Aircraft in a Huddle

The public controversy which has been raging for some time over the allocation of a contract for a jet airliner by the British European Airways has led to an interesting discussion of the value of " paper designs " and company groupings. B.E.A.'s specifications were for a short-haul jet airliner to carry 95 to 100 passengers, cruising at subsonic speeds of around 600 m.p.h. with a full pay load for 1,000 miles. The projected order was a relatively small one of about 20 aircraft. But 50 to 60 per cent. of all air travellers fly distances within the specified range, particularly in North America and Europe, and there would therefore be a very large world market for an aircraft of this type.

The chairman of the Hawker Siddeley Group, Sir Thomas Sopwith, spoke some blunt words on the controversy that has arisen over the allocation of the B.E.A. contract for a short-haul jet airliner. He described the group resulting from the association with the Bristol Aeroplane Company as " the most powerful single unit which has ever materialised in the British aviation industry. Indeed," he said, " competition is dwarfed by this fusion of forces." Hawker Siddeley entered into agreements with Bristol and set up a joint company to spearhead the B.E.A. project in order to comply with the government policy under which future orders would be awarded, a policy which was laid down by the Minister of Supply in the House of Commons on December 2. Competing for the same order are the de Havilland company, who have appeared less keen on the prospect of rationalisation but with whom a group which included Fairey Aviation, Hunting Aircraft, Handley Page, Saunders-Roe and Rolls-Royce were said to be ready to co-operate.

From an unspecified source, rumours spread that the B.E.A. preferred the de Havilland design but that the Government favoured the Hawker-Bristol group because they had complied with their advice on groupings. It was shortly after this that Sir Thomas Sopwith spoke out on what he called a " bad case of technical smog " and " ill-founded gossip." His argument was simple enough: the Hawker Siddeley-Bristol combination dwarf their rivals; it is on a footing fully competitive with the great American corporations in money, men and material resources of development and production; it is a merger in line with government policy; it is nonsense to talk of the technical superiority, on paper, of one aircraft over another, especially when the basic designs submitted to the B.E.A. were " almost exactly alike; " and that the eventual quality of the product is determined by the quality and strength of resources in terms of knowledge, experience and facilities which are placed behind the project.

The de Havilland group would be far from equal in resources and strength to Hawker Siddeley but there is another possible grouping —Vickers-English Electric-Blackburn Aircraft, which would be of comparable size, though it has been stated that no such group has yet been formed. It was later reported that de Havilland would join Hawker Siddeley and Bristol in a consortium, to meet the Government's wishes for the largest possible groupings. The Hawker group itself has grown immensely in the past few months. Their interests were described by Sir Thomas Sopwith as ranging " from nails to supersonic aircraft." Yet the group's aircraft factories comprise about 20 per cent. of Britain's aircraft industry.

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Men of Steel

This is the season of annual general meetings for steel companies. Last week five of them, including two of the largest, reported to their shareholders. United Steel and Dorman Long joined forces with " Mr. Tube " of Stewarts and Lloyds in warning the Labour Party to keep off de-nationalised industries. Sir Walter Benton Jones, chairman of United Steel, spent over half his total space on the subject. He declared the opposition of his board " to any further interference with ownership or management of the steel industry." The industry, he said, is a manufacturing and trading industry, not a service. It could gain nothing and lose much by public ownership and he had no wish to see his company's business become " the business of Parliament." Sir Ellis Hunter, chairman of Dorman Long, spoke more briefly and not so emphatically on the subject though he is obviously concerned with the fact that " the immediate effect of this threat of nationalisation is to make it more difficult to secure additional capital for further modernisation and expansion."

Most of the companies view the future with mixed feelings, despite last year's excellent results. Sir Walter Benton Jones anticipates a slackening in the " hitherto overwhelming world-wide demand for steel " and has some doubt what the position may look like next spring " if monetary restrictions are enforced to a point where industrial production suffers or is only maintained by reductions in stocks." Sir Ellis Hunter reports well maintained order books and satisfactory consumption but warns that " it would be optimistic to assume that the effects of the credit squeeze and the high Bank Rate will not be felt." Sir John Green, chairman of Thomas Firth and John Brown, finds " a distinct slowing down in the pace of new business " although his company's order book is satisfactory. The demand for forgings was keeping at a high level, the demand for rolled bars " experienced a serious contraction " and subsequent improvement due to the recovery in the motor industry's sales. Sir John finds it difficult to find " clear and convincing evidence that the improvement will be maintained against world trends."

South Durham Steel and Iron Company, who experienced a 59 per cent. increase in trading profit, have committed themselves to a capital expenditure of £5·7 million. Their chairman, Mr. B. Chetwynd Talbot, described the first phase of a new steelworks for the production of steel plate to be erected at a cost of £43 million on a 530-acre site at West Hartlepool. Mr. Talbot anticipates a continued rise in demand for steel plate and forecasts even better results for next year. The high level of activity in shipbuilding, oil pipeline construction and heavy engineering ensures that demand will continue to exceed supply for some time to come.

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Views on Car Exports

Astonishingly confident predictions are being made by motor manufacturers on the industry's export performance during 1958. In his statement to the annual general meeting of the British Motor Corporation, Sir Leonard Lord said that (in his company) " we feel sure that the limit of world demand for motor vehicles is not yet in sight; on that assessment we base our optimism for the future and our policy of expansion." A similar statement by Sir Patrick Hennessy is quoted in the note on company profits on this page. Mr. Brian Rootes confidently expects that 1958 can be " a vigorous and prosperous period for the industry." But Mr. Rootes' statement was qualified by the words " given settled trading conditions." The facts of the situation, which is discussed in greater detail in " The Engineering Industries: Automobile Engineering " in this issue, are that world trade is declining and commodity prices have slumped.

The effect of this state of affairs on car exports cannot be avoided: already New Zealand has had to impose full import controls involving a 25 per cent. cut in car imports during 1958. Other importing countries have little alternative but to follow suit. Sir Leonard Lord himself emphasises that the industry will " always be particularly susceptible to world conditions and Government controls." One would therefore expect car demand in export markets to react strongly and quickly to the first signs of a downturn. Yet the fact remains that exports during the second half of last year rose to record heights, even during the fall in commodity prices. Particularly were they high to the United States, despite the fall in demand for home-produced cars in that country. This is the most baffling of industries, which has rarely conformed in the past to the expectations even of its own leaders.

The outlook for commercial vehicles, particularly the heavy type, has become uncertain during the past few months, particularly on the home market. Guy Motors' new chairman, Mr. Arthur L. Blower, commented that cancellation of Government contracts, restrictions on hire purchase and other deliberate measures to restrain investment are seriously affecting turnover. In the export markets demand continues at a fairly satisfactory level but price competition has become most keen.

Construction

PLANNING NEW THERMAL GENERATING STATIONS

Significance of Constructional Conditions

It would appear from a lecture delivered by Mr. J. Pimpaneau on December 18 to a joint meeting of the Supply Section of the Institution of Electrical Engineers and the British Section of the Société des Ingénieurs Civils de France that the problems connected with the planning and construction of large modern thermal generating stations in France are being dealt with on lines analogous to those being followed in this country. Water power will, however, continue to be developed and this fact introduces the further problems of how best to choose between thermal and hydro-electric stations to satisfy requirements. A basic factor in the planning of future stations, Mr. Pimpaneau emphasised, was the effect of such items as the cost of buildings and plant and of the thermal efficiency on the price per kilowatt-hour generated. Since fuel represented 60 per cent. of the total costs debited to the station, every effort should be made to reduce its specific consumption by improving the thermal efficiency. Manufacturers, in association with Electricité de France, had carried out research to this end with the result that the net specific consumption of stations commissioned during recent years had been reduced from 3,300 kilocalories to 2,300 kilocalories per kilowatt-hour.

Since the establishment cost represented about 20 per cent. of the charges on the station, the planning of the main buildings and other civil engineering work required careful study. The present-day practice was to place all the heavy equipment on one floor and, as this required a relatively large ground area, at Bordeaux, the boilers and main equipment had been placed out of doors and were connected by light bridges.

A generating unit with an output of 115 to 125 MW, of which 40 were to be built, had been standardised. Standardisation was also being applied to the principal auxiliary machines and to the voltage of the driving motors.

The operating staff for a modern station was 0·4 men per megawatt compared with four men per megawatt in the older stations. This reduction had been effected by the adoption of the unit system and by performing all the coal handling in one shift.

As regards the future the outlook was relatively bright. The fixed operational costs would be reduced owing to the increase in the rating of the plant, while the cost of the civil engineering work should also fall. Further research should, however, be directed to improvements which would lead to a reduction in fuel consumption and consequently of its cost. Investigations into the adoption of higher pressures and temperatures should also be pursued.

LESS INDUSTRIAL BUILDING

The latest figures for approvals of new factories show that the last quarter of 1957 was no better than the preceding two quarters for the planning of future construction. The approvals were lower than for any quarter since 1953 apart from the exceptional quarter after Suez. These and earlier figures have generally confirmed the estimate published by the Board of Trade last September which forecast a fall by some 9 per cent. in industrial building during 1958. How this will affect civil engineering contractors is not yet clear, since most of the larger firms have extensive overseas activities and since the Government might at any time alter their policy on fixed investment. The situation was very clearly analysed by Sir Thomas Moore, chairman of Eastwoods Limited, manufacturers of building materials, in his speech to the company's shareholders. In his view the dominating factor in the situation is the Government's restrictive policy.

The announcement last September that the total amount to be spent by central and local government and the nationalised industries would be held at £1,500 million for each of the next two years—an expenditure which accounts for about 40 per cent. of all fixed investment in Britain—will have, in Sir Thomas's view, " an all-pervading effect on the national economy and the building industry in particular." The intention to secure a progressive slowing down in housing by 1959 to 1960 (backed by financial measures and instructions to local authorities), the decisions to make " substantial overall reductions in power station development " and the spreading of the nationalised undertakings' programme over a longer period will certainly cut deeply into the volume of business available to the building and contracting industry in the United Kingdom. " As soon as the current work already planned and in the pipeline has been completed," Sir Thomas concludes, " a further recession in the demand for building materials must be expected." Already, he pointed out, men and machines are being forced out of production and he expressed the hope that the need for restrictions would not last long.

Contractors will doubtless have a difficult time, as will their suppliers, in 1958-59. The expenditure of £100 million in two years on road construction will help them, as will the Thermal Insulation Act which becomes law towards the end of the year. But the industry will have to wait, perhaps a full two years from now, before it can resume its growth.

CONTRACTORS' PLANT: A MAKER'S POINT OF VIEW

A new heavy-duty dumper with a capacity of 20 cub. yards has been developed by the Aveling-Barford group after three years of intensive market and technical research, much of it carried out in North America. This provides the group with an entry into the heavy contractors' plant market and may prove to be the start of a recovery in the group's fortunes. The dumper will be available with either a 330 h.p. supercharged Rolls-Royce oil engine or, alternatively, with a British-built Cummins Diesel. Six forward speeds (3 to 30 m.p.h.) and one reverse speed will be obtainable from the single-lever gearbox. The air-operated brakes will be supplemented from the exhaust, using the same pedal. Production models should be available later this year.

In his annual statement, the chairman, Mr. Edward Barford, observes that the demand for the parent company's products—road-rollers, small and medium dumpers, grinders and other contractors' machinery, has continued to fall. Group trading profits are down for the fifth year in succession, to just below £684,000 (in 1956 they amounted to £955,000). Only successful results of subsidiary companies, among them Goodwin Barsley, who make quarry plant and concrete mixers, and Barford Agricultural, whose products include market-garden tractors and equipment, prevented the fall from being greater. In Mr. Barford's own words, they were " of considerable assistance in improving the overall result."

Mr. Barford complains of inadequate Government support in certain overseas markets, particularly in South America where " the competition is fierce, but the prizes are high." The company's failure to obtain competitive credit terms from the Export Credit Guarantee Department prevents any break-through in those markets and Mr. Barford's complaint " that exhortations from ministerial circles for increased exports, accompanied by platitudinous instructions on how they can be accomplished, are useless without credit facilities equivalent to those available to foreign competitors." It is, of course, a fact that these countries have few if any sterling reserves and have been very unsatisfactory markets for British engineering firms since the war.

The situation is unlikely to right itself within the next few months and Barford will have to expand sales in other fields if they are to reverse their present unsatisfactory order position. The forthcoming road programme could be the way out, and the new heavy dumper, if successful, might well provide an item of plant hitherto imported from dollar sources.

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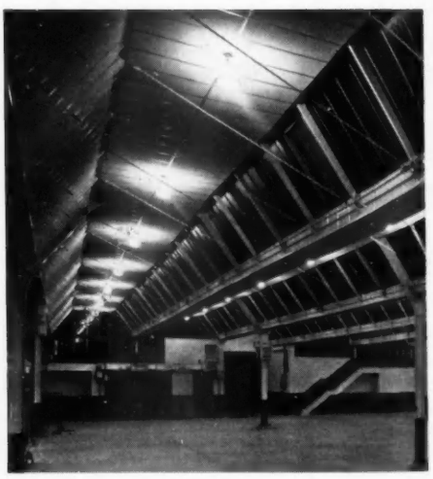
HIGH-BAY LIGHTING

Shown in the accompanying illustration is a Holophane high-bay lighting installation brought into use recently at the new factory extension of de Havilland Propellers Limited, at Stevenage, Hertfordshire. The installation, supplied by Holophane Limited, Elverton-street, Westminster, London, S.W.1, uses the latest development in 1,000 watt MBF/U lamps. The fittings are at 28 ft. 6 in. mounting height, spaced 24 ft. 6 in.



by 24 ft. 6 in., the area being lighted measuring 210 ft. by 150 ft.

An extremely efficient light distribution with a good general overall intensity of 25/28 lumens per sq. ft. was planned for the working plane, as the task envisaged was to be of an exacting nature, consisting mainly of engineering precision assembly. A reading taken prior to the installation of machines gave 35 lumens per sq. ft. on the working plane; 69 Holophane prismatic high-bay fittings have been installed in the new building, providing a satisfactory degree of ceiling brightness and avoiding a tunnel effect. The general wall colour is light cream.

The average light output of the new lamp, which is designed to run on normal mains voltage of 230, is in the region of 45,000 lumens. The rated life is about 5,000 hours. The savings in maintenance compared with a tungsten installation are therefore attractive.

Marketing

WAR ON THE PRODUCT PIRATES

Repeated charges of "piracy" in designs, pouring in from many countries including Britain, have stung the Japanese Government into vigorous defence as well as some preventive action. Most of the patent infringements and deliberate copying have been done by small firms and in many cases could have been the result of ignorance either of what is copyright or of international practice. After the blaze of publicity of recent weeks, few manufacturers in Japan can now remain ignorant of these things. Another explanation has been the small firms' inability to create original designs, either due to lack of confidence or of resources. The recent creation of a textile design centre in Osaka and a pottery design centre in Nagoya, where original designs are registered by manufacturers and certificates of origin delivered, has made copying less necessary and easier to detect. Complaints are dealt with directly by manufacturers' associations and there has been an improvement in both the speed and the fairness with which they have been settled.

More action is contemplated by the Japanese Government to stop design "piracy," both by its own nationals and by foreign competitors in respect of Japanese designs. Information has been collected of many cases of the latter, particularly in the Near and Far East, and South America, affecting products such as fountain pens, lighters, hosiery and ladies' wear. A protest to the Italian Government was made recently against sales in Italy of imitation Japanese camphor in boxes bearing the label "made in Japan." This is even worse than the case reported last September by Pollard Bearings Limited. Their managing director, Mr. John King, gave full details (including photographs) of a carton containing ball bearings manufactured in Japan identical with the Pollard pack except for the exclusion of the word "genuine" and the substitution of "made in Japan." It sold in Far Eastern markets for half the price of the British-made bearings.

This type of copying generally leads to a great deal of bad temper. In this case Mr. King complained that the lower quality of the article, "not made of the correct steel," easy to pass on to persons unfamiliar with the techniques of bearing manufacture, "will do a great damage to our prestige in the field of light engineering." In the textile industries such cases of copying are so frequent that manufacturers no longer bother to seek publicity. There is no doubt that the creation of co-operative design organisations by the Japanese Government will go far to eliminate what has become a widespread habit. Penalties for the infringement of patents are being increased and the life of patents extended from 10 to 15 years. To be protected a foreign design will still have to be registered in Japan but this is also the case in Europe and North America. The criterion of a patent's originality will be based not only on publication in Japanese technical journals but in foreign ones as well.

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Engineer-Salesmen

Salesmen are slowly coming into their own as competition returns and the flow of orders for many engineering firms is becoming less than the volume of deliveries. Selling can no longer be done by a part-time director or two and more emphasis is being placed on sending to users and potential users of a firm's products a qualified engineer who is familiar with the application as well as with the technical characteristics of the products themselves. This point was made very strongly by Mr. Roger S. Falk, who has had a long and successful career as an advertiser, marketing consultant and expert on sales promotion, when he delivered one of the Loudon lectures on engineering production in Glasgow. "The engineer-salesman," he said, "especially in the export trade, can be an ambassador capable of doing more for the prestige of Britain abroad than all the British Councils, trade fairs and missions rolled together."

Mr. Falk advocated a greater interchange of staff between the sales and manufacturing sides of industry and far closer co-operation between the various departments of a company. A successful design policy, he argued, which led companies into new fields and enabled them to take advantage of the latest technical advancement, was much more likely if those concerned with design, production, purchasing, sales and finance all took part in its formulation.

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On Films

Sales training films were described as "vital weapons in the battle for overseas markets" by the publicity manager of the British Tabulating Machine Company when he introduced films "How to Sell Quality" and "Overcoming Objections" at a London branch of the Incorporated Sales Managers' Association. His advice was to use films "as an integral part of the sales training programme." Both films were provided by the G.B. Films Library who have classified a large number of films into six main categories: industrial management training, management-worker relations, work study and work simplification, accident prevention and welfare, salesman training and automation in industry. Their comment in their catalogue, "film is a visual aid which is particularly appropriate to technical education," is especially valid for education in technical salesmanship and application engineering. It can present the product to the potential user in its context, showing where, how and from what materials it is produced, how it is inspected, packed and despatched.

A major step forward has been made in overcoming the language barrier in making films for foreign markets. A new magnetic-optical film projector has been developed by G.B.-Bell Howell which enables the quick and cheap production of films dubbed in any language. This is done by recording the background noises direct from the optical sound track on to the magnetic track and adding the commentary separately. The commentary can be wiped off easily without affecting the background noise and one in another language substituted.

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Commodity Boomerang

The reaction of countries producing raw materials and foodstuffs to the fall in world commodity prices was not long delayed. In the New Year, New Zealand announced the imposition of import controls including a reduction of 25 per cent. in the former 1958 quota for motor vehicles imported c.k.d. and a cut of 50 per cent. in the quota for assembled vehicles, motor cycles and cycles. About 1,000 items are scheduled for control, including machinery. Typical cuts are 25 per cent. for electric motors and dairy machinery, 50 per cent. for watches, 75 per cent. for electric irons, razors and cameras. A number of engineering products, however, have been placed in the category "A" schedule—including metals, ball bearings and much heavy machinery—which means that licences will be granted to the amount applied for from non-dollar sources or Japan.

New Zealand accounts for 4 per cent. of British exports (or £128 million in the first eleven months of 1957) and is a most important market for vehicles. Australia announced in December that the fall in the prices of wool and foodstuffs might lead to the imposition of tighter import controls early this year. In view of the very inadequate long-term capital inflow, heavy cuts are almost inevitable, which could amount to more than £100 million on the imports from this country. Thus there is the beginning of a retrenchment by commodity producers, and a characteristic of this retrenchment is that the most severe restrictions will be placed on the import of dollar goods, for the reduction in American commodity purchase has already had the effect of producing an acute shortage of this currency.

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Rumblings of the Rouble

Soviet leaders made it quite clear in Cairo last month that Russia was prepared to offer economic aid to the "uncommitted countries of Asia, Africa, and the Middle East." Preliminary offers may already have been made. Loans, credits and barter agreements amounting to thousands of millions of roubles are expected. Unlike American aid, no outright grants are expected. The Russian methods are designed to ensure what Sir John Russell, president of the Le Play Society, called "the need for underdeveloped countries to establish standards of honesty in accepting foreign aid" is met. Sir John thought that the advantages in the Russian methods of providing, instead of many loans, supplies in kind and experts to manage them were considerable.

Low interest rates—2 to 2½ per cent.—very long-term credit, repayment in kind and the offer of capital goods (with application engineers to install them and train operatives) is proving very attractive and much is made of the claim that there are no political strings attached. All this is very cleverly done and appeals even to committed countries. Argentina's despatch of an economic financial mission to Moscow this month and also to east European countries, is evidence that capital plant plus long-term credit plus ridiculously low rates of interest will take a lot of countering. The Argentine mission is said to be interested in buying locomotives, railway materials and accessories, commercial vehicle and bus chassis, electric generating equipment, oilfield and coal-mining equipment and steel plant. This is a formidable list of goods Britain could well supply.

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Tickling the Victim

Lubrication is a deadly serious matter—especially to the maintenance engineer. So is selling lubricating oils. But there is no subject so serious that a dash of colourful humour is out of place and, in advertising lubricating oils for use in different industries, Peter Kneebone, on behalf of Shell Mex and B.P., has succeeded in treating his subject in a light-hearted and amusing fashion that has much of Heath Robinson and Emett.

Bright in colour and full of an involved complexity (plus plenty of artistic licence) Kneebone's cartoons crusade under the title of "Oiling the Wheels of Industry." (If you don't know them, there will be one—on paper-making—in ENGINEERING next week.) So popular have these advertisements become that copies can be obtained—free—from the lubrication department of Shell Mex and B.P. at Shell Mex House, Strand, London, W.C.2. Better still, they can be had collected together in booklet form—also free—from the same address. In this way you also get an instructive 400 words about each of the industries caricatured. It is ideal "take-home" reading for the family and makes an excellent peace offering for late arrival.

Automobile Engineering

NEW BRITISH SPORTS RACING CAR: THE WILLMENT

By Gordon Wilkins

Sweeping sharp edged lines of the Willment give it a characteristic appearance. Front end and tail panels form complete units which are hinged for easy access to chassis. Wheels have Borrani rims on bolt-on magnesium alloy centres.

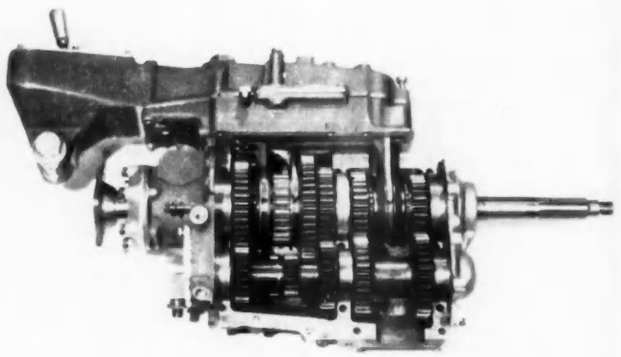
Front suspension with wishbones, coil springs, telescopic dampers and anti-roll bar. Rack and pinon steering. Climax twin-camshaft engine with two twin-choke S.U. carburettors fed from separate gearbox. Radiator header tank behind carburettors. Oil tank alongside driver, fuel tank on opposite side.

At the Brands Hatch circuit near London on December 26, Jack Brabham won the Formula Libre race and established a new lap record in a Cooper Formula 1 with Climax engine of 2·2 litres, but in third place was a new sports car of 1,500 c.c. competing for the first time. This was the Willment-Climax driven by Stuart Lewis-Evans, and it was built by John Willment, son of the director of a large firm of civil engineers in England.

The car is low built and well proportioned, powered by 1,500 c.c. Climax engine with twin overhead camshafts. Chassis is of lightweight tubes and the four-wheel independent suspension is by unequal length wishbones, with coil springs and Armstrong telescopic dampers. Steering is rack and pinion and brakes are Lockheed with 11 in. by 2¼ in. (27·9 by 5·7 cm.) drums which are in magnesium alloy with radial fins for cooling. The oil tank is mounted to the offside of the driver's legs and the 6½ gallon (30 lit.) fuel tank balances it on the other side. The battery is behind the rear brakes, which are mounted beside the differential, and there is enough space at the back for a spare wheel and eventually for a supplementary fuel tank.

Transmission is by Borg and Beck twin plate clutch and five-speed gearbox made by Willment specially for racing. The pinions are straight cut and those for the four faster speeds are in constant mesh. There is no synchromesh. The differential, also made by Willment, is enclosed in a magnesium alloy housing and the bolt-on wheels are of the same material.

The price of the car without tax will be £2,450. I hear a Formula 2 single seater is also under consideration with five-speed box at the back, in unit with the differential.



Five-speed racing gearbox with constant mesh gears for four ratios. First and reverse are automatically blanked off after use, and cannot be re-engaged until the small catch in front of the gear lever is released.

DESIGNED FROM THE MAN OUTWARD

Car Controls Criticised

Ergonomics, the study of human work and control operations, now has its own journal,* and the first paper to appear in it was one which discussed the many deficiencies in the design and layout of vehicle controls, instruments and seats, which diminish driver efficiency. Entitled "Human Limitations and Vehicle Design," it was based on an investigation of American cars, buses and commercial vehicles carried out by Mr. R. A. McFarland of the Harvard School of Public Health, a well-known investigator in the field, but the findings have a wider application.

"If instruments and controls are considered as extensions of the driver's sense organs, nervous system and body appendages, it is reasonable to expect that machines should be designed from the man outward," says the author, and makes the point that static control layouts based upon anthropometric averages are not adequate; they must be supplemented by dynamic studies with drivers of varying stature in action, to ensure that they can all operate efficiently. He cites one American truck in which a tall driver had to change gear before he could get his foot on the brake pedal. In some, only 5 per cent. could comfortably reach and operate the handbrake; in others, only 60 per cent. could get their knees between pedals and steering wheel. Seat adjustment ranges were frequently inadequate, and instruments were often difficult to see.

Other points criticised included driving vision and the layout of electrical controls. Faulty arrangement of pedals produced muscle-straining movements of the foot between brake and accelerator, and it was found that automatic transmissions reduced driver activity by 5 to 25 per cent., allowing greater concentration on traffic hazards.

In sunny climates, tinted glass reduces glare and helps to keep the interior cool, but at the same time introduces a night driving hazard as it absorbs 25 to 30 per cent. of the light, against 12 per cent. for ordinary safety glass. Objects just perceptible without the glass must be 1·45 times as bright to be seen through it. This can be serious for elderly drivers, as for every increase of 13 years in age, the intensity of a light must be doubled to make it just perceptible; the oldest subjects investigated required a light intensity at threshold levels nine times that needed by the young ones.

The speed of dark adaptation also slows down with advancing age; in cars it is constantly being disturbed by approaching headlamps, but unduly bright non-adjustable instrument lighting is also to be avoided. This point is made with special force in another paper on fatigue and stress among drivers of fast Diesel railcars, where it was found that after switching on the cab lights to consult his time-table, an elderly driver with normal dark adaptation might be driving virtually blind for two minutes, on lines where there may be 70 unguarded level crossings in 100 miles.

Here in Europe, instruments are generally more legible than those in the United States, and driving vision is better because the vehicles are smaller, but otherwise the partnership

* *Ergonomics*, official organ of the Ergonomics Research Society, published by Taylor & Francis Limited, 18 Red Lion-court, London, E.C.4

between engineer and stylist has not been noticeably more successful than in the United States. Continental designers are well ahead in producing controls which allow horns, indicators, side lamps and headlamps to be operated without taking a hand from the steering wheel, even on the cheapest cars, but on one popular model the seats have had to be redesigned after 20 months because they inflicted crippling discomfort on many drivers.

Britain pioneered the adjustable steering column, which is unfortunately disappearing with the shrinkage of the market for medium- and high-priced cars, but there are many badly designed seats, and there are pendant pedals on which no adequate pressure can be exerted by a woman wearing a high-heeled shoe. The wrap-round windscreen has sometimes done no more than move the centre portion out to where the flies and raindrops are permanently in focus, and there are cases where the same range of vision could be obtained by fitting a flat glass across the existing pillars, with a big improvement in visibility, especially in fog. There are two recent models on which it is necessary to turn the ignition key with one hand and then use the other to operate the starter, and it is not unusual to find that one hand must be used to release the handbrake, and then the other for the gear lever. The specialist in ergonomics should find plenty to occupy him in a field which probably affects more people than any other.

WHERE VAUXHALL AND B.M.C. CARS GO TO

The announcement that during 1957 exports of motor vehicles by both Vauxhall Motors and the British Motor Corporation reached record levels underlines the marked recovery made by the motor industry during the past 12 months which is discussed in greater detail elsewhere in this issue. A general discussion of motor-car exports also appears in Weekly Survey. The recovery in export markets was, in fact, more pronounced than in the case of home sales, and for the first ten months of 1957, exports of passenger cars and chassis accounted for nearly 55 per cent. of production as compared with 50 per cent. in 1956.

In the case of Vauxhall, exports of private cars and commercial vehicles rose by one-third in 1957, while production rose by 18 per cent. to a total of 150,200 vehicles, comprising 91,450 cars and 58,750 vans. There has been a steady increase in production as the company's £36 million expansion programme nears completion.

In 1957, the British Motor Corporation exported 49·2 per cent. of its total production, an export ratio which is well below that for the industry as a whole. Nevertheless, the value of the Corporation's exports, including service parts, was nearly £100 million. B.M.C. exports had been more severely hit in 1956 than those of Vauxhall and the B.M.C. export figure for 1957 represented an increase of nearly 32 per cent., compared with the previous year. In 1957, the Corporation was responsible for nearly one-third of total United Kingdom vehicle exports.

B.M.C. have been particularly successful in North America to which they exported 58,925 vehicles valued at £69 million, including spare parts. The latter figure represents an increase of 94 per cent. over 1956 and among other factors reflects the great success achieved in the United States market by the Morris Minor 1000.

The motor industry as a whole has good hopes of maintaining a high level of exports in 1958 in spite of a number of adverse factors. The chairman of B.M.C. pointed out at the annual general meeting in December that owing to increased steel prices and higher wages it had been necessary to raise home and export prices by up to 4 per cent. and that it would be some time before the effect of these price changes became apparent. The motor industry may also be one of the chief sufferers from the decision of the New Zealand Government to reimpose import licensing. On the other hand, the United States recession does not appear as yet to have affected sales of British cars in the United States and there are good grounds for hoping that expanding sales to North America will counterbalance any decline in exports to Commonwealth countries due to falling commodity prices.

NEW HILLMAN HUSKY

The Hillman Husky, the compact business-and-pleasure car of the Rootes group has been completely transformed, with larger, more powerful engine and longer, roomier body. Frontal appearance and basic style now conform with that of the Minx, but the wheelbase, although increased slightly, is still shorter.

An increase of 2 in. (5 cm.) on the wheelbase permits more leg room for rear passengers, and although the height is slightly reduced, headroom has been increased by the new unit structure with step-down interior. The longer tail provides a larger luggage platform, and it is claimed that carrying capacity is increased by 110 lb. (50 kg.). Separate tip-up front seats give access through the two side doors to the bench-type rear seat. With four adults on board, there is space for 300 lb. (136 kg.) of luggage, on a flat platform 7½ in. (19 cm.) longer than before. The rear seat folds flat in a single movement, giving a flat cargo platform which offers 41·5 cub. ft. (1·175 cub. m.) of freight space. Manufacturers claim carrying capacity of 600 lb. (272 kg.) with two adults in the car, or 672 lb. (300 kg.) with driver only.

It weighs more than the previous model, and the side-valve engine has therefore been scrapped in favour of the larger overhead-valve Minx unit. The new high-torque camshaft is fitted, but the compression ratio is lower than on the Minx (7·0 to 1) to permit use of normal grade fuels. Power output is 43 b.h.p. against 37·5 b.h.p. for the old Husky, an increase of nearly 15 per cent., and a maximum speed of 70 m.p.h. (112 k.m.h.) is said to be allied to exceptional fuel economy. Basic price in England is £465, an increase of £35 over the previous model. Purchase Tax raises price for British home buyers to £698 7*s*.

Management

WORK STUDY AND MODELS SPEED CHEMICAL PROCESS DESIGN

As a result largely of the interest in work study stimulated by the first Work Study Conference organised by the Association of British Chemical Manufacturers in 1953, productivity in Britain's chemical industry has shown a marked increase during the last few years. In May last year the A.B.C.M. held a second conference at Harrogate, the proceedings of which have been published recently (*Work Study Conference for Senior Work Study Practitioners and Works Managers*, Harrogate, May 23 to 25, 1957, Association of British Chemical Manufacturers, Cecil Chambers, 86 Strand, London, W.C.2. 13*s*. 6*d*. post free).

Two papers in particular aroused great interest at the conference, both by representatives of Imperial Chemical Industries Limited. Both discussed the design of chemical processing plant: "Work Study in Design," by Mr. A. L. Marsden, assistant chief engineer of I.C.I. Dyestuffs Division, and "The Use of Models in the Design and Construction of Chemical Plant," by Mr. E. H. Salisbury, senior design engineer (oil), I.C.I. Billingham Division.

One of the earlier plant-design projects on which I.C.I. applied work study (some four years ago) was carried out in parallel with traditional design methods. The study based on traditional approach was carried out by an engineer with 25 years' experience; the work-study approach by an engineer with only three years' experience. Both took about two to three weeks to complete their respective studies and their final choice of plant arrangement was not widely different—but that arrived at by the work-study approach made rather better use of existing equipment, and gave much fuller consideration to the manning requirements, as well as being completely documented.

The steps in the work-study approach are, briefly as follows: firstly, to prepare a record of the basic ideas, however immature: a simple flow sheet with a brief specification of each plant item, and a material-type flow process chart. A detailed critical examination of these two documents is set out on a tabulated sheet—what is to be achieved, when, where, how and by whom; why; all other possible alternatives; and the selection, from these, of what should be done. This gives a reasonably complete, but not necessarily final, idea of the plant required; and from this can be deduced the manpower need. A multiple activity chart is then prepared indicating the number of work units in each hour and the geographical distribution of work units, which gives a guide to the desired plant arrangement as well as the number of men required.

The dominant factors determining plant layout should now be apparent, and the engineer can select, from all possible alternatives, the best positions for the key items, and subsequently the less important items. Rough floor plans can be sketched, and also man-type flow process charts and work-study flow diagrams. At this stage a simple model is of great value, making possible method studies of maintenance—which may lead to modifications in the model layout—and construction. Not until the design is finally agreed, on the basis of rough sketches, charts, and simple model, is any work commenced in the drawing office.

The work-study technique, I.C.I. conclude, speeds up plant design and makes better use of engineering staff with only limited experience; the full recording of the decisions leads to greater confidence, and repeated changes in plant design are avoided; in most cases the overall efficiency of the plant design is improved—in particular, savings in the costs of materials, handling and storage have been achieved.

The simple models discussed above, which are cheap, easily built, and quickly altered, eliminate the need for general-arrangement schemes, and make for much quicker decisions on layout. They stimulate valuable criticism from plant-operating, maintenance and construction engineers, medical, safety and fire officers, and enable manning problems to be studied at an early stage. After the final layout has been settled, another type of model has proved invaluable—a relatively costly detailed scale model including all equipment pieces, interconnecting piping, and associated valves, fittings and instruments. The need for intricate general-arrangement drawings of complex piping and electric-cable runs is eliminated by a final-design model—detail drawings being made from the model, a procedure which results in better-quality design. The model also aids consultation with the process, maintenance, work study and construction departments, and enables the last-named to undertake forward planning and then to carry out erection more smoothly. After completion of the plant, the model is useful for training plant operators, and it helps production management to analyse and determine at a much earlier stage than usual how the plant should be operated.

Continuing **Management**

THE ENGINEERING INDUSTRIES

What The Future Holds for

SHIPBUILDING

In the first report of this series, in our issue of January 3, we considered the outlook for exports, raw materials and wages in respect of the engineering industry as a whole. The second review, last week, considered the prospects for particular industries:—agricultural machinery; locomotives and rolling stock; machine tools; textile machinery; and coal and electricity. This week the report is concerned with shipbuilding; motor-cars; and aircraft. A subsequent issue will conclude with reviews of the light electrical, wire and cable industry; and general and constructional engineering.

Despite the drastic fall in freight rates after the Suez crisis, pressure on British shipyards was still high in 1957. During the first nine months of last year, they received orders amounting to 1,498,000 gross tons, an increase of nearly 20 per cent. compared with the corresponding period of 1956. On September 30, 1957, the total order book of the British shipbuilding industry stood at 6,971,000 gross tons, valued at £975 million. This was more than 1·3 million tons above the figure for September 30, 1956, and represents between five and six years' work. From the diagram it can be seen that tonnage laid down for export in 1957 has also shown a welcome reversal from the downward trend over the preceding few years.

On the face of it, therefore, the outlook for the industry is exceptionally good. A closer examination of the scene in 1957, however, gives rise to some disturbing questions. The reduction in new orders placed during the past few months has been shared by shipyards in most countries throughout the world and as yet there is little cause for concern on this score. What is more disturbing is the apparent inability of the British shipbuilding industry to meet its commitments quickly and efficiently.

The table printed below gives the world picture in terms of gross tonnage launched and under construction at the end of September, 1957. Comparison with the previous year's figures is distinctly unfavourable for British shipyards. It shows that United Kingdom launchings were only 7 per cent. greater in 1957 than in 1956 and that total tonnage under construction in British yards rose by a meagre 6 per cent. in the same period. Both these figures are well below the average increase shown by all countries taken as a whole. World tonnage launched in the period January to September, 1957, expanded by 32 per cent., while tonnage under construction rose by 25 per cent. Expansion by the Japanese industry was particularly marked during the period under review. Tonnage under construction in Japanese yards rose by 24 per cent., while launchings rose by 47 per cent. Indeed at current rates of expansion, the United Kingdom may slip to third place in 1958 behind Japan and Germany in terms of tonnage launched. What are the reasons for the failure of the British shipbuilding industry to increase its rate of expansion?

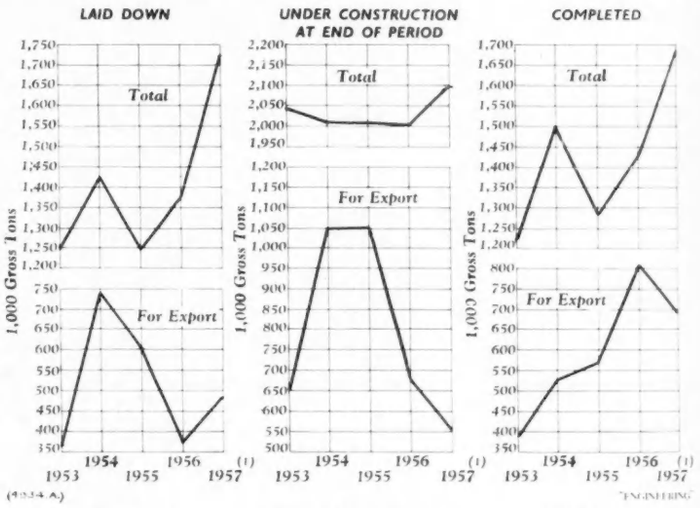
To some extent, the reason lies with the slowness of British yards to adapt themselves to mass production techniques. Much of the Japanese success, for example, is accounted for by the fact that, by widespread standardisation, they have been able to employ a good deal of prefabrication in the construction of large oil tankers and other bulk-cargo ships. The British industry has been slow to adopt such techniques in its yards for a variety of reasons. Management is said to be diffident in its attitude towards prefabrication and admittedly there are many difficulties associated with putting such techniques into practice without interfering with normal activity at a time when the shipyards are working to capacity. Opposition from the trade unions, however, has had a good deal to do with the slow introduction of improved techniques in British yards. Whether labour troubles in the shipbuilding industry have been the fault of management or labour is a very open question, but there is no doubt that strikes and stoppages have bedevilled this industry probably more than any other since the war. In particular the Cammell-Laird episode in 1956 was only one of a number of demarcation disputes—probably the core of the problem. In view of the complexity of existing demarcation agreements a radical re-organisation of shipbuilding methods might greatly aggravate the difficulties. In the long run, however, such a re-organisation might prove the quickest way of reaching a final settlement of this vexed question.

Nevertheless, it is encouraging to record that, despite all the difficulties, several shipbuilding companies are going ahead with plans both to expand existing capacity and to extend prefabrication techniques in order to build the larger ships which are in ever growing demand. Hawthorn, Leslie and Company announced recently that they are to spend £1 million in expanding their shipbuilding and repairing yards at Hebburn-on-Tyne with a view to producing larger ships. At about the same time Lithgows revealed details of a £2 million re-organisation plan for their Kingston shipyard at Port Glasgow which it is hoped will make it one of the most efficient and modern yards in the world. A new prefabrication shed will be built to make units of up to 60 tons, while the fitting-out basin will be lengthened and deepened and the yard completely re-designed. It is intended ultimately to build 65,000-ton oil tankers at this yard and immediate provision has been made to construct tankers of up to 35,000 tons deadweight. Many other companies are going forward with plans which will enable them to meet the demand for larger vessels, particularly tankers. Of these schemes, the one announced by Cammell-Laird in February, 1957, is probably the largest, envisaging an expenditure of £17 million over an 8 year period.

Re-equipment to meet future demands in this connection is a matter of some urgency. The size of ships, particularly tankers, is likely to go on increasing, since it has been shown that there is a clear and proportionate reduction

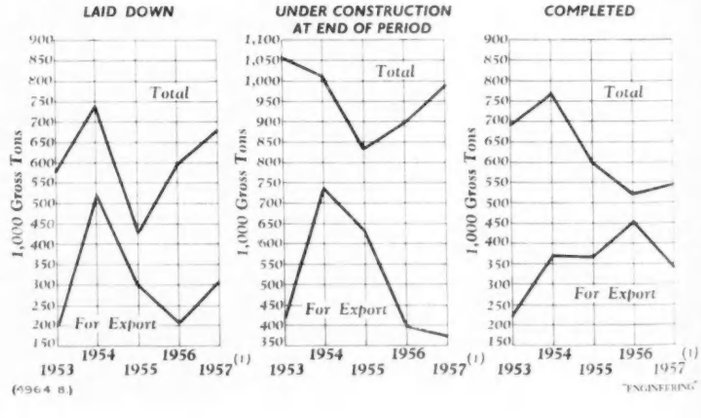
World Shipbuilding: Gross Tonnage Launched and Under Construction, 1957

	Launched Jan.-Sept., 1957		Under construction Sept. 30, 1957	
	No.	Gross tons	No.	Gross tons
United Kingdom ..	191	952,712	339	2,240,731
Other Commonwealth countries	33	68,430	58	183,908
Belgium	11	86,342	18	155,320
Denmark	25	125,587	30	178,538
Finland	29	37,774	77	226,172
France	48	333,988	66	521,306
Germany	302	872,482	234	827,220
Italy	47	381,798	109	881,202
Japan	313	1,725,067	209	1,480,255
Netherlands ..	147	320,137	175	606,165
Norway	59	159,220	86	322,473
Spain	50	97,214	92	237,069
Sweden	58	432,254	65	490,949
U.S.A.	41	243,971	39	601,178
Other countries ..	77	176,050	140	398,067
Total ..	1,431	6,013,026	1,737	9,350,553



Merchant shipbuilding in the United Kingdom (Thousand gross tons).

(1) Estimated on first 10 months



Tanker construction in the United Kingdom (Thousand gross tons).

(1) Estimated on first 10 months

in the cost per ton-mile of oil shipped as the size of the vessel increases. Average running costs are reduced since the required propelling power per ton declines as the size increases, while the size of the crew remains virtually unchanged. British Petroleum, who ordered 26 new tankers last year, specified that seven of the vessels would be of 65,000 tons d.w. each, with a further nine of 50,000 tons d.w. each. The average size of tankers ordered by B.P. in 1957 was not far short of 45,000 tons.

Despite the growing world demand for super-tankers, it is still believed in some quarters of the shipping industry that the time is not yet ripe for independent owners—in this country at least—to contemplate ordering tankers much in excess of 40,000 tons. Mr. Basil Mavroleon, chairman of London and Overseas Freighters, said in June, 1957, that the potential cost and loss of earnings time could be enormous if a long tow proved necessary from the scene of a major breakdown or mishap, and that the scarcity of dry-dock facilities of adequate capacity in the United Kingdom made the development of super-tankers a premature move. There is a good deal of truth in Mr. Mavroleon's latter statement and inadequate docking facilities have been a major bottleneck faced by this country's shipping industry for some time. Lack of space has, of course, restricted the possibilities of extending both dry-dock and wet-berth facilities to take large tankers, and shortage of capital has been accentuated by the high level of Bank Rate. Nevertheless, a number of schemes are going forward. The biggest concerns Milford Haven where it is intended to build two dry docks, five wet repair berths and an oil discharge pier capable of taking tankers up to 100,000 tons d.w. At Southampton, plans are under way to enable 65,000 ton tankers to be handled, while on the Clyde, a new jetty is to be provided capable of accommodating ships up to 100,000 tons d.w. A new oil berth is contemplated on Merseyside for taking vessels up to 65,000 tons d.w. or up to 100,000 tons d.w. with draught restriction, and a number of other sites are being considered. Meanwhile, companies in Japan, Germany and Norway announced further plans in 1957 for the construction of docking facilities to accommodate tankers up to 100,000 tons d.w.

Apart from the increasing accent on size, the most interesting technological development over the past few years has been in the possible application of atomic power to marine propulsion. The United States was the first country to apply nuclear energy to ships in the submarine Nautilus, and the Russians are building a number of atomic-powered submarines. The U.S.S.R. claimed another success last month in the launching of a 25,000 ton atomic-powered ice-breaker, the Lenin. This was the first surface vessel propelled by nuclear energy to be launched in the world. Its power is provided by pressurised-water reactors, developing 42,000 s.h.p.

The main problem of using reactors for ship propulsion is to bring down the cost to a level comparable with conventional costs using oil fuel, which have been estimated at about 0·5*d.* per s.h.p.-hour. It is known that power costs in the large graphite-moderated gas-cooled stations of the United Kingdom electricity authorities are in general below this figure, but is it unlikely that such plants can be scaled down for economical use in smaller ships. Less adaptation might be necessary for large ships but for smaller vessels it has been thought necessary to develop other types of reactor, such as the pressurised-water system. Two further types are being investigated by the Atomic Energy Authority in conjunction with the British Shipbuilding Research Association. One is the organic-liquid-moderated reactor, which might be built in small sizes to give outputs of about 20,000 s.h.p. or under; the other is the heavy-water gas-cooled reactor. The relative advantages and disadvantages of using different types of reactors were discussed very fully in ENGINEERING, vol. 184, pages 444 and 569, 1957.

Meanwhile, the Admiralty has also been active in placing development contracts with Vickers Nuclear Engineering Limited, for the development of a pressurised-water reactor for submarines. Interest in submarine oil tankers also developed in 1957. It has been pointed out that such a vessel, travelling under water, meets few of the hindrances encountered in surface travel and can therefore move more quickly and efficiently. Atomic power is a necessity here, since the power source must be of a type which does not require air for its operation. The Japanese Ministry of Transportation announced early in 1957 a 10 year programme of research on nuclear propulsion for merchant ships, and one of the basic designs on which work has been started by the Mitsubishi Heavy Industries Company under this programme is for an atomic-powered submarine tanker capable of cruising at 22 knots submerged. In the United Kingdom, Gel Tankers of London announced recently that they had reached agreement with a Swiss firm of naval architects for preliminary investigations into the development of 68,000 ton nuclear-powered submarine tankers.

What the Future Holds for

MOTOR VEHICLES

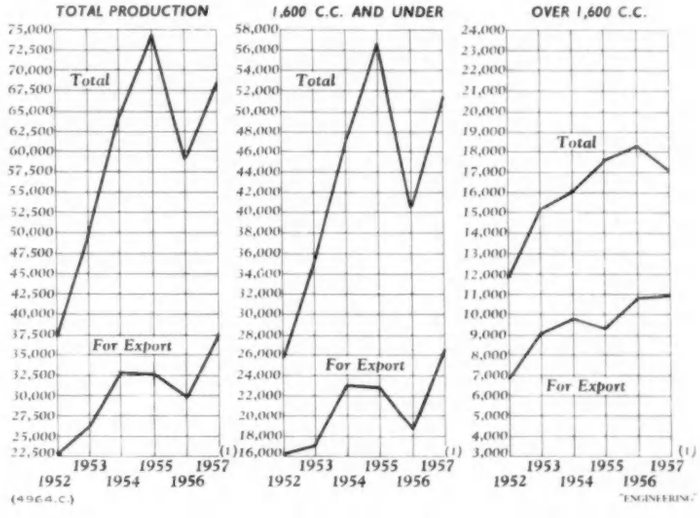
Uncertainty as to the future clouds the success of motor manufacturers in 1957. The accompanying diagram shows that the motor industry made a remarkable recovery from the setbacks of 1956. However, it is believed in some quarters that the effects of the credit squeeze and high Bank Rate have yet to make their full impact on manufacturers of motor vehicles and it is doubtful whether the rate of expansion in 1958 will be as high as was the case in 1957. Much will depend upon whether the Bank Rate will be maintained for any length of time at its present level. Much will also depend upon whether the Chancellor of the Exchequer sees fit in his budgetary proposals in the spring to reduce what has been described as the penal level of purchase tax upon new motor vehicles. Mr. Alick Dick, president of the Society of Motor Manufacturers and Traders, said on the eve of the last Motor Show in October, that potential sales of motor vehicles in the home market could probably be estimated at about 750,000 cars a year but that, in his view, the 60 per cent. purchase tax effectively reduced this demand to between 400,000 and 500,000 vehicles per annum.

Nevertheless, the recovery in motor vehicle sales both in this country and to overseas destinations has meant that the major British manufacturers were able on the whole to maintain or increase their profit margins last year. The net profits of Fords totalled over £7 million in the year ending June, 1957, compared with £5·9 million in the previous year. Net profits of Rovers also increased by over 5 per cent., to £808,000, while Standards net profit rose by virtually the same amount in the year ending August, 1957. In contrast to this general trend, however, net profits of the British Motor Corporation fell by almost half in the year ending July, 1957, while the Rootes Group made a net loss of £250,000 in the same period, which showed a sharp fall from the net profit of £871,000 made by this company in 1956.

The maintenance of adequate profit margins is a matter of necessity if the motor industry is

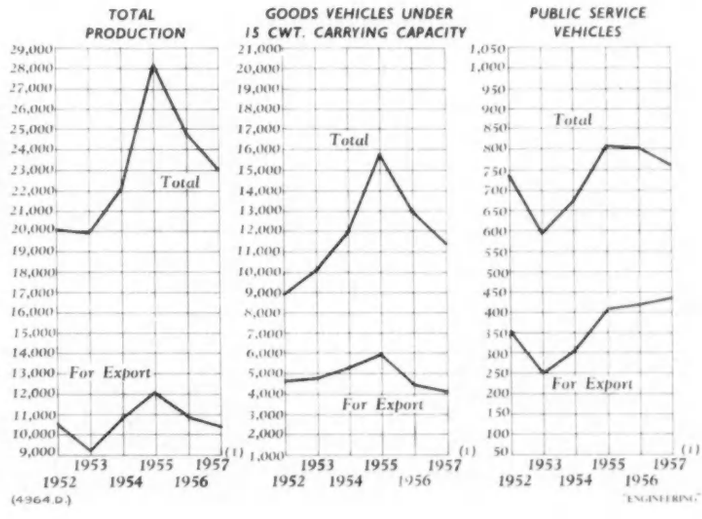
Production of passenger cars and chassis 1951-1957 (Monthly average numbers).

(1) Estimated on first 10 months



Production of commercial vehicles and chassis 1951-1957 (Monthly average numbers).

(1) Estimated on first 10 months



Continuing Management

United Kingdom Exports of New Vehicles, Chassis and Parts (Value £1,000)

	Cars		Commercial vehicles		Total	
	1956	1957*	1956	1957*	1956	1957*
Australia	14,947	12,695	9,464	7,133	24,411	19,829
New Zealand	9,688	10,747	4,088	4,270	13,776	15,017
Canada	7,882	11,527	867	703	8,749	12,230
Union of South Africa	6,939	12,519	7,131	8,470	14,070	20,989
Rhodesia and Nyasaland	3,809	5,078	3,283	3,000	7,092	8,078
Ghana	822	876	3,464	2,543	4,286	3,419
Nigeria	1,204	1,525	5,530	3,353	6,734	4,678
Other Commonwealth countries	15,295	16,905	21,517	18,489	36,812	35,394
Irish Republic	2,409	2,655	1,730	948	4,139	3,603
Sweden	5,802	7,716	355	385	6,157	8,101
Denmark	2,813	3,159	1,774	2,299	4,587	5,458
Netherlands	3,196	3,323	2,711	2,217	5,907	5,540
Belgium	5,346	6,236	2,022	1,724	7,368	7,960
United States of America	16,182	37,887	951	276	17,133	38,163
Other foreign countries	16,964	20,746	26,534	37,710	43,498	58,456
Total	113,298	153,594	91,421	93,322	204,719	246,916
Parts	—	—	—	—	54,788	56,054
Grand total	113,298	153,594	91,421	93,322	259,507	302,970

* Figures for 1957 are based on the first nine months annual rate

to maintain its rate of expansion in order to meet the challenge of the European Free Trade Area. It has been alleged in some quarters that the United Kingdom motor industry may not be able to compete in the Free Trade Area, owing to the low level of capital investment as compared with manufacturers in other countries. While this criticism is not altogether valid in relation to the last few years, it may be doubted whether British motor manufacturers can maintain adequate margins for investment in new plant and equipment if the present high Bank Rate continues. At present, however, they are on the whole well placed.

Fords is the only major company in the industry which is producing to capacity and it is said that there will be no further expansion in plant and equipment by this company until 1959, when their large £60 million 5 year programme starts to mature. The other large groups, on the other hand, have a good deal of room for expansion of production. The British Motor Corporation, which has virtually completed its main expansion and re-equipment programme, has a total potential capacity of about 12,500 vehicles a week, and is currently producing around 11,000 vehicles a week. It has still, therefore, a good deal of capacity to take up, although the Corporation continues to invest about £7 million a year in new plant in the United Kingdom and overseas. Vauxhalls have also virtually completed their expansion plans and are now running at about two-thirds their potential capacity. From the point of view of adequate capacity, and provided the high Bank Rate does not mean further cuts in investment, the motor industry may therefore be regarded as on the whole prepared at the moment for the challenge of the Free Trade Area.

On the other hand, as Mr. Dick has pointed out, the United Kingdom industry will not be able to compete effectively unless its production costs are kept to the minimum. In addition to the high rate of purchase tax which, by reducing demand, decreases the possibility of long low-cost runs, the industry continued to experience labour troubles last year. One outstanding example was, of course, the refusal of the unions to accept standardised working conditions in the Ford subsidiary of Briggs Motor Bodies in order to increase productivity and to improve liaison between the two companies. Despite the fact that this would have added £75,000 a year, to their wage takings, the unions maintained that they could not accept this change since they thought that it would lead to compulsory overtime. As was pointed out in this series last year, the future success of the motor industry in this country is in a large part dependent on the co-operation of the unions.

Despite the difficulties that the motor industry faced in 1957, it can be seen from the accompanying Table that conspicuous success was achieved in the export market, where United Kingdom exports of motor cars increased by 40 per cent. compared with 1956. The United States was again the leading customer of the United Kingdom motor industry, despite continued intensive competition from German and French manufacturers and from the increasing interest shown by the American companies in the production of a small low-cost car. The British Motor Corporation have done particularly well in the United States market with their new Morris Minor 1000. In the first ten months of 1957, sales of this model amounted to over £3 million—an eightfold increase over the corresponding period in 1956. The Motor Show, held at Earls Court in October, 1957, resulted in very large orders from North America.

Increasing sales to the Dollar Area may help to offset a possible reduction in demand from the Commonwealth in 1958. This may arise from the current fall in raw material prices which is bound sooner or later to affect the purchasing power of primary producers. In the case of commercial vehicles, there has already been a fall in exports to the Commonwealth and this trend may spread to passenger vehicles in the coming year.

Criticism has been levelled at British manufacturers in the past for failing to design a vehicle specifically suited for particular markets. This may have been in part the reason for the decline in exports of both private cars and commercial vehicles to Australia in 1957. The Volkswagen and other Continental models are considered eminently suitable for Australian roads. It was, therefore, encouraging to note that last year B.M.C. announced that they had spent £A12 million in developing a plant at Sydney Park for the production of a car designed specifically for the Australian market. This model will be available in 1958, by which time B.M.C. will have spent around £A20 million on the plant and equipment necessary for its development. Meanwhile, Volkswagen have formed a company known as Volkswagen Australasian Pty. with a capital of £A10 million to construct a manufacturing plant at Clayton which will replace existing assembly plant. The B.M.C. move has not come too early.

The current recession in raw material prices is having its effect on the investment plans of primary producers, and in 1957 this was reflected in a falling demand for commercial vehicles. For this and other reasons, there was a particularly heavy fall in orders from the United States, but the fall was shared by the majority of Commonwealth customers. This trend will probably continue in 1958 with a few possible exceptions. In 1957, exports of public service vehicles continued to expand slightly and may expand further in 1958. Two leading British manufacturers have had encouraging success in selling such vehicles abroad. Leyland Motors, for instance, announced in December, 1957, that it had won the largest single order for British buses with fully automatic gearboxes. In this connection the company is supplying 125 vehicle chassis worth £350,000 to the Transport Department of the New South Wales Government. Earlier in 1957, Leyland also announced an order for 80 Royal Tiger Worldmaster chassis from the Municipal Transport Trust of Adelaide. The Associated Equipment Company have also scored a success in Persia, where they are to supply 250 double-decker buses for use in Teheran. Besides being the first vehicle manufacturer ever to supply double-decker buses to Persia, A.E.C. can congratulate themselves on breaking into a completely new market, hitherto controlled by German companies. There is still no cause for resting upon laurels, however, for earlier in 1957, the Daimler-Benz Company secured a £4 million order from the Teheran Transport Board for 750 buses.

What the Future Holds for

AIRCRAFT

The aircraft industry has now reached a crucial stage in its post-war development. The defence cuts forecast at the beginning of 1957 have been made and the future of the industry appears very uncertain. From all the available indications, the aircraft industry must contract by an appreciable amount over the next few years; the question remains as to how far this process can be allowed to go. Published figures are unsatisfactory in estimating trends in the industry, since they exclude all military aircraft except those exported. A more reliable indication is possibly the trend of employment in the industry. In June, 1951, the total employment in the aircraft industry was 161,700. With the on-set of rearmament this figure rose rapidly over the next few years until it reached a peak in January, 1957, of 266,600. Even this does not complete the picture, since an appreciable number more are employed in the manufacture of parts and accessories of aircraft. The total number directly or indirectly concerned with aircraft manufacture is therefore at least 300,000.

The process of contraction is very much more painful and difficult than that of rapid expansion; the decline in numbers employed so far since the cuts were first announced has not been dramatic. The latest figures available, for September, 1957, show a total direct employment of 261,300. However, the change of atmosphere is marked. During 1956, aircraft manufacturers were competing extensively for the services of such qualified technical staff as were available, and there was an acute shortage, both of skilled labour and of technical manpower. This situation has now largely ceased.

While, for security reasons, no overall figures are published of total British aircraft production, it has been estimated, probably with some degree of accuracy, that civil aircraft account at present for only about 25 per cent. of total aircraft production. The aircraft industry must be considered from two points of view. The first is the necessary defence requirements of the United Kingdom; the second is the contribution which the industry can make to the country's exports. Considering the second of these viewpoints first, exports of aircraft and aircraft engines and equipment have risen steadily over the past few years, until the industry is one of the six largest exporting groups in the whole of British industry. The estimated increase in exports in 1957 is not quite so dramatic as in the previous year. It has been estimated on the basis of figures for the first nine months that total exports of aircraft and equipment in 1957 will have amounted to £104·5 million, compared with £101·5 million in 1956. It was hardly to be expected that the marked increase recorded in 1956 should have been continued, and it is

very satisfactory that this high level of exports has proved to be no flash in the pan.

There is one trend in the details of these figures which is of considerable significance. Though the total export figure has risen by about £3 million, this rise has been accounted for by a 30 per cent. rise in exports of engines, which more than offset a decline of nearly £10 million in exports of aircraft. In the first nine months of 1957, exports of engines can be estimated to be running at an annual rate of nearly £39 million, compared with £60 million for aircraft and parts. Very appreciable export orders for engines have been received during the past year or two and with the number of American and French jet airliners ordered to be equipped with British engines the aero-engine manufacturers seem set for a period of rising prosperity.

On the first score, therefore, the aircraft industry has been performing well over the past few years and would seem set to continue and improve on this performance in the immediate future. This is, however, by no means the whole picture, even so far as the export market is concerned. A considerable proportion of British aircraft exports consists of military aircraft. The exports now being achieved are the result of research and development paid for in the first instance largely for defence of the United Kingdom. The present level is being maintained by the exports of such aircraft as the Hunter, for example. While Hunter orders have been received in quantity during the past year, this cannot continue indefinitely, and without the backing of research and development devoted to supplying aircraft to the R.A.F., these exports clearly cannot be maintained in the future. A case in point is the Saunders-Roe SR177. This aircraft was originally conceived for the R.A.F., but in view of the 1957 Defence White Paper was no longer required. A small requirement for the Royal Navy did not justify the extensive development costs, but work proceeded during 1957 on the strength of considerable interest in the machine from the West German Government. Had the potential German orders materialised, production for the Royal Navy could have been economical. However, the German orders did not materialise and Government support was withdrawn, resulting in the most serious redundancy problem yet experienced by the aircraft industry in recent years. There have been a limited number of private ventures and semi-private ventures in the military aircraft field. Perhaps the most outstanding of these recorded in these columns last year was the Hawker supersonic fighter, the P 1121. This bold venture has, however, been shelved, owing to lack of support.

The gross output of the aircraft industry is probably in the region of £400 to £500 million a year, so that the present level of exports is at the most 25 per cent. of the total output. Some idea of what this means in terms of the proportion of output accounted for by defence needs can be gauged by a study of the pattern of orders for the Viscount. This aircraft, in addition to selling very well to the British air corporations, has enjoyed an almost unparalleled success in export markets. The result of this is that of total orders amounting to £143·25 million, £117·25 million are accounted for by orders overseas, an export ratio of 82 per cent. While the Viscount can be reckoned one of the major successes of the post-war period in the aircraft industry, the total sales of the Viscount represent a fair measure of the order of sales required to make a success of a modern aircraft and, in addition, to make a profit for those who have financed its development. The home market for civil aircraft is of necessity very limited compared to the world market and clearly an export ratio, if not as high as 80 per cent., at least of appreciably above 50 per cent. must be aimed at. This may then be compared with the present 20 to 25 per cent. Though this possibly gives an over-simplified picture of the change necessary were the aircraft industry to retain its present output while converting to all-civil production, broadly speaking, it would imply raising exports from the current level of £100 million a year to around £300 to £400 million. Such an expansion could not be achieved at short notice.

Further to this, any progress in aircraft design presupposes a very considerable expenditure on research and development. Hitherto, both basic research and important development projects have been undertaken and financed to a large extent by military requirements. With the curtailing of defence expenditure, the question of who is to finance basic research and general development becomes of prime importance. It is satisfactory to note that the Government is at least sufficiently aware of the problem to have set up an inter-departmental committee to investigate the whole problem.

A certain amount of the business lost by the aircraft industry as a result of the defence cuts will, of course, be offset by the stepping up of the guided missile programme. It is doubtful, however, whether this can make up the whole loss or even a very large part of it.

So far as can be reasonably foreseen, therefore, it is certain that the aircraft industry must contract, and there has been increasing discussion over the past year as to whether the industry should not integrate its widespread forces into a more logical and efficient system. This idea is, of course, not new, but it appears finally to have received official sanction in view of Government statements towards the end of 1957 that they would officially encourage the integration of the aircraft industry by a selective placing of new orders. Such a process of course, is more easily said than done; preliminary indications suggest that companies may be more willing to join forces for a particular project than to accept integration. Various ideas have been put forward as to the number of companies which should exist independently. At present there are about sixteen independent manufacturers of aircraft, and one authority has gone so far as to suggest that there is room for only three companies. What appears to be needed, however, is not so much a financial integration of companies as a genuine pooling of the technical resources available.

Suggestions for rationalisation of the aircraft industry took more concrete shape in the latter part of 1957, following the issue of a specification by B.E.A. for a medium-range jet airliner required for service in 1963-64. This aircraft was to be essentially a private venture and the expenditure required was estimated as being of the order of £20 million; this, with the rapid delivery necessary if the machine was to compete in export markets, made it appear very likely that more than one company would need to co-operate in the project. This aircraft is therefore of great importance in setting the future pattern of the aircraft industry. The pooling of technical resources is by no means devoid of difficulties; the problems that can arise when widely separated design offices work on the same project should not be under-estimated. However, in the increasingly competitive conditions which will be experienced, it is probable that some re-grouping is essential.

The Transport Aircraft Requirements Committee has been considering all possible transport needs in the Services, the Corporations, and the independent airlines for the next ten to fifteen years. Apart from aircraft already ordered and the short to medium-range jet airliner, this includes the development of a long-range freighter, a supersonic civil airliner on which a research study is being made by a consortium; and the future development of the Bristol Britannia, the Fairey Rotodyne which made its first flight in November, and the new Bristol Orion turboprop engine, all of which are existing projects.

Competition from foreign manufacturers has hitherto been experienced mainly in the field of long-range transport aircraft and has come from the American manufacturers, whose development costs have to a very appreciable extent been paid for by United States defence contracts. The experience with the SR177 indicates perhaps that a new era of competition for military aircraft contracts is opening. This competition is not confined to the American manufacturers.

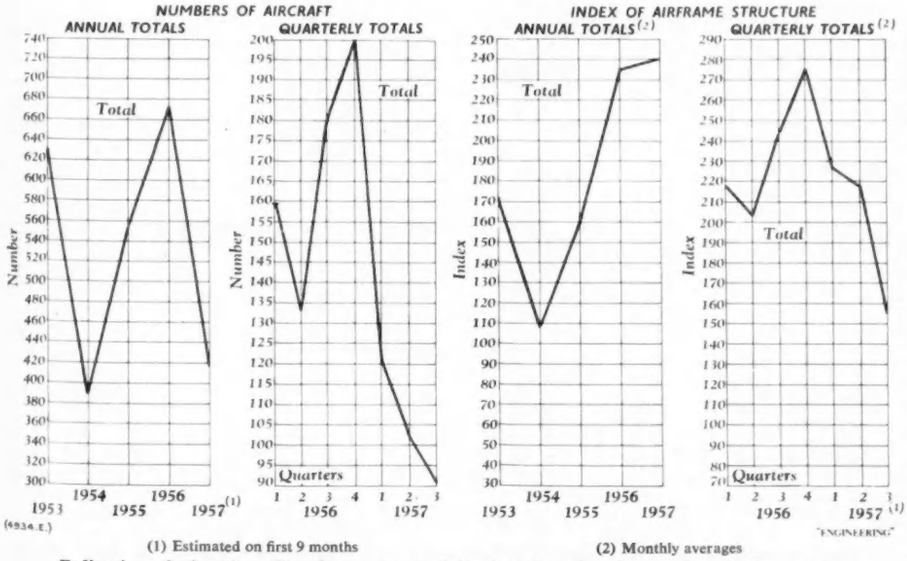
The French aircraft industry, whose exports in 1956 amounted to only £7 million, have made striking advances during 1957. Between the end of the war and September, 1957, the French obtained export orders worth about £105 million. The rapid expansion is shown by the fact that two-thirds of this total was obtained in 1957 and less than 10 per cent. before 1956. In spite, therefore, of their relatively small size at present compared with the British industry, the French are emerging as powerful competitors. It has also been widely suggested that, particularly in view of the Common Market, there may be growing co-operation between the Germans and the French in the aircraft field.

Overall, therefore, the aircraft industry faces a period of great difficulty which will probably extend over the next two years at least.

United Kingdom Exports of Aircraft and Equipment (£1,000)

—	1955	1956	1957*
Aircraft and parts	39,652	71,759	60,019
Engines	22,277	27,903	38,585
Electrical appliances ..	2,260	2,682	3,197
Tyres (outer covers) ..	648	688	804
Aeronautical instruments ..	1,367	1,429	1,916
Total	66,204	101,461	104,521

* Estimated on first nine months



(1) Estimated on first 9 months

(2) Monthly averages

Deliveries of aircraft. The figures cover civil aircraft and military aircraft for export.

Research and Development

TESTS ON STRUTS IN THE ELASTIC AND PLASTIC RANGES

By K. B. Ayers, B.SC., M.SC.(ENG.), A.F.R.AE.S., *and R. C. Coates*, B.SC.(ENG.), PH.D., A.M.I.C.E.

The buckling load of a long strut with elastically-restrained ends fixed in position, Fig. 1, may be expressed as the buckling load of a pin-ended strut of equivalent length. In such a strut, of flexural rigidity E I

$$E I \ddot{y} = M - P y$$

and hence

$$y = A \sin \alpha x + B \cos \alpha x + \frac{M}{P}$$

where

$$\alpha^2 = \frac{P}{E I}.$$

Taking the origin of co-ordinates at the point O, the centre of the undeflected length, substitution of the appropriate boundary conditions gives

$$P_{cr} = - \alpha k \tan \frac{\alpha L}{2} \quad . \quad . \quad (1)$$

where P_{cr} is the crippling load. Rearrangement of equation (1) gives $\frac{k L}{E I} = - \alpha L \cot \frac{\alpha L}{2}$, and if

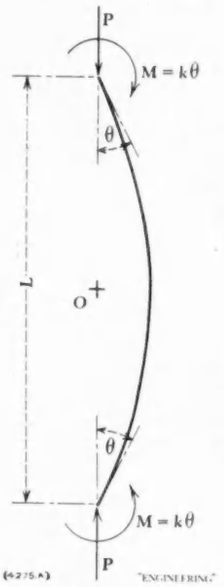


Fig. 1 (left) Load system for strut with ends rotationally restrained.

Fig. 2 (right) "Equivalent length" reduction factor for end restraint.

we now write $P_{cr} = \frac{n^2 \pi^2 E I}{L^2}$, that is, if the length of the equivalent pin-ended strut be defined as $\frac{L}{n}$, then $\alpha = \frac{n \pi}{L}$ and

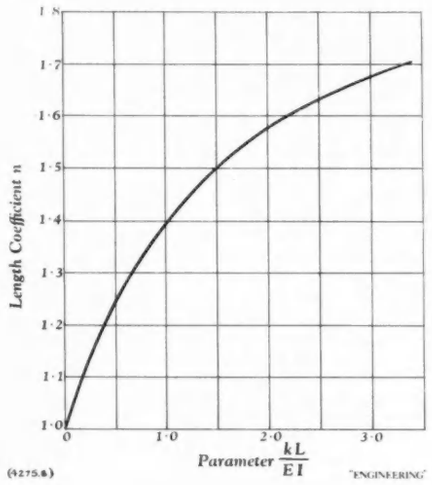
$$\frac{k L}{E I} = - n \pi \cot \frac{n \pi}{2}. \quad . \quad (2)$$

Equation (2) may be used to calculate the parameter n, in terms of the known physical constants of the strut and the restraint, and thus allow the determination of the cripping load for all values of k intermediate between $k = 0$ (pinned ends) and $k = \infty$ (when the strut is position and direction fixed at its ends, and $n = 2$). A graph showing the relationship between n and the dimensionless function $\frac{k L}{E I}$ is shown in Fig. 2.

For experimental work, it was decided that differing degrees of elastic restraint might best be provided by coil springs. Two end fittings were prepared (Fig. 3) which consisted essentially of a small lever, rotating about a ball-bearing fulcrum. The struts to be tested, of tubular section, fitted over a small spigot on one end of the lever, while two springs (which could be initially prestressed) acted normally to, and on opposite sides of, the other lever arm. When no springs were used, it was assumed that rotationally free end conditions would be simulated, while replacement of the springs by two 2 in. diameter steel cylinders was considered to impose a degree of restraint approximating to complete end fixity. The struts used were of $1\frac{3}{8}$ in. O.D. by 17 s.w.g. drawn Duralumin tube, to specification T.4., with ends machined square to the axis, and with ends opened out for a length of 0·8 in. to a diameter of 1·277 ± 0·0005 in. to ensure a good fit on the end spigot.

The testing machine was hydraulically operated, had a total capacity of 5 tons, and was equipped with spherically-seated platens at both top and bottom of the vertical specimen, which were used in tests on struts in the pinned end condition. In the design of the end fittings it was arranged that the centre of curvature of these spherical seats should coincide with the centre of rotation of the spring-loaded lever.

Prior to the commencement of experimental



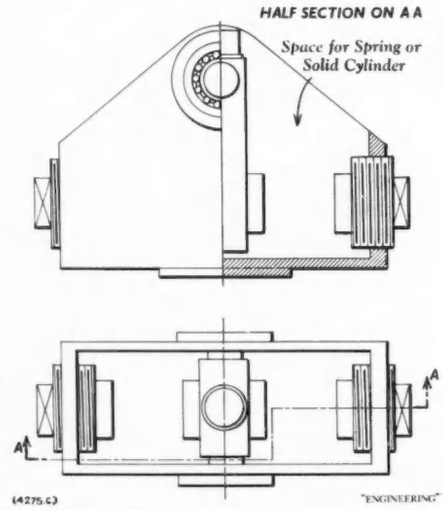


Fig. 3 Design of end fitting to give rotational restraint.

work upon the struts, careful beam deflection tests were made, under four-point loading, of the Duralumin tube, to give a figure for the flexural rigidity of the test section. The average value was $5{\cdot}28 \times 10^5$ lb.-in. units, compared with $5{\cdot}31 \times 10^5$ lb.-in. units, based on the nominal dimensions of the tube, and the value of E quoted by the manufacturers. The stiffnesses of coil springs used were measured during dead-weight tests, deflections being recorded on two dial gauges at opposite sides of the coils. Matching pairs of springs were used to give elastic restraints, k, of 10,400 lb.-in., 21,350 lb.-in. and 47,200 lb.-in. per radian.

During all strut testing in the elastic range, load readings as given by the machine dial were checked against those calculated from the means of the readings of two electrical resistance strain gauges placed on opposing sides of the strut at the span centre. The difference between these strain-gauge readings during the early stages of any test may be used to predict the magnitude of the crippling load without the necessity of carrying the test to its ultimate conclusion. Similar graphical extrapolations of the load-deflection relationship (e.g. the "Southwell plot,"[1]) may be used for the same purpose, and, in all tests the central deflection was measured by a dial gauge for each increment of load.

If it be assumed that all struts possess some initial bow, which can be represented as a curve such that

$$y = \Sigma_1^{\infty} \delta_n \sin \frac{n \pi x}{L}$$

then it may be shown that the measured central deflection y_c, due to an axial load P, is given by the equation

$$y_c = \frac{P}{P_\epsilon - P} \delta_1$$

where P_ϵ is the Eulerian buckling load of the strut, and δ a constant. This can be written in any of three forms:

$$y_c = P_\epsilon \left(\frac{y_c}{P}\right) - \delta_1$$

$$P = P - \delta_1 \left(\frac{P}{y_c}\right)$$

$$\frac{1}{y_c} = \frac{P_\epsilon}{\delta_1} \left(\frac{1}{P}\right) - \frac{1}{\delta_1}$$

and it may be seen that, in all, a graph of the left-hand quantity against the expression in brackets gives a straight line from which the crippling load may be obtained by extrapolation. Experience showed that the first of these three

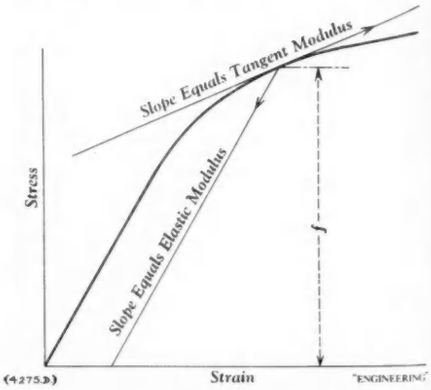


Fig. 4 Difference in moduli for increasing or decreasing strain.

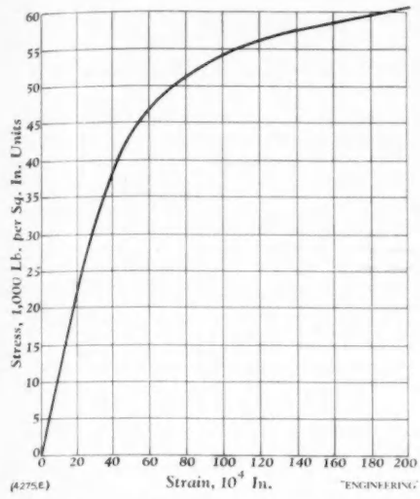


Fig. 5 Stress/strain curve for tubular strut.

methods is to be preferred on the grounds of accuracy, although the second is more convenient. The third equation is not recommended, since the crippling load is finally obtained as the reciprocal of a very small intercept. In experimental work it has been found that some movement of the strut frequently occurs during the early stages, and Lundquist[2] has suggested a modification of Southwell's line, using the relationship

$$y_c - (y_c)_A = \frac{y_c - (y_c)_A}{P - P_A}(P_c - P_A) - [(y_c)_A + \delta_1]$$

where the symbols used previously retain their original significance, and where $(y_c)_A$ is the measured central deflection under some datum load P_A.

During tests on short columns, stresses may be developed in the strut which exceed the proportional limit of the material. Engesser[3] suggested that, in this case, the crippling load might be derived using the normal Eulerian formula, provided that the modulus of direct elasticity used in the expression should be the tangent modulus for the material appropriate to the direct stress. Later theories (propounded initially by Engesser after consideration of Considere's work and, later, by Southwell[1], postulate that some intermediate value of reduced modulus should be used, since, for some direct stress f, Fig. 4, although fibres on the concave side of the strut would respond with a stress-strain relationship governed by the tangent modulus, those on the convex side would obey the normal relationship of elasticity. All experimental work has confirmed the accuracy of predictions based on the tangent-modulus theory, despite the apparently preferable assumptions inherent in the use of the reduced modulus, and this paradox has been resolved by Shanley.[5] He showed that it was possible for bowing to commence in a strut, and for all the material contained therein to undergo increasing compressive strain, provided that this bowing occurred as the load increased. For an ideal strut, initially perfectly straight, this bowing will not occur until the tangent-modulus load is reached, but strain reversal and failure will take place immediately thereafter. Later work by Duberg and Wilder[6] has shown that that the lateral deflection of struts with initial curvature or eccentricity begins to increase immediately on the application of load and that the tangent-modulus load will be the upper limit of the strain reversal load in such cases. For most materials, failure will follow immediately.

In order that failure of the struts under test might be predicted in the plastic range, careful measurements were made of the stress and corresponding strains in short lengths of the Duralumin tube, using two dial gauges to record the compressive strain. The average stress-strain curve thus obtained is shown in Fig. 5. Values of the tangent modulus were obtained on the assumption that between any three adjacent points, the stress-strain curve lies on a parabolic curve. A further graph, Fig. 6, shows the relationship between the stress f, as ordinate, and the ratio between stress and tangent modulus, $\frac{f}{E_T}$, as abcissa. It will be noted that this abcissa is dimensionless, and the curve may be used for all struts of the given material, irrespective of the size and shape of the cross-section. Using the original Engesser formula

$$P_{cr} = \frac{\pi^2 E_T I}{L^2}$$

and if $P_{cr} = A f_{cr}$ and $I = A k^2$, where A is the appropriate cross-sectional area and k the least radius of gyration, then

$$\frac{f_{cr}}{E_T} = \pi^2 \left(\frac{k}{L}\right)^2.$$

Fig. 6 may be used to give the crippling stress, as ordinate, for any strut of known slenderness ratio. Superimposed on this graph are the experimental results obtained, using various degrees of end restraint, from which it will be seen that, in all cases, the tangent-modulus crippling load represents an upper limit to the failure load of the strut. The same results are shown, in more conventional form, in Fig. 7, where the crippling stress, as ordinate, is plotted against the slenderness ratio as abcissa. In the particular case of this material, failure occurs at loads lower than the Eulerian value for slenderness ratios below approximately 65.

An analysis of the results of extrapolated plots on the various specimens tested, gives interesting results. It is assumed in the early mathematical analysis that the strut in question obeys the normal law of proportionality between stress and strain, and that the deflection curve might be represented by a series of sine functions. This implies that no bending moment (the second differential of deflection), and hence no eccentricity of load, exists at the ends of the strut. In all the struts tested under these conditions, the crippling load determined by extrapolation was in close agreement with that ultimately obtained experimentally, the deviation being never greater than 4 per cent., and, most generally, of the order of 2 per cent. For shorter struts, in which the crippling stress occurs in the plastic range, graphical methods over-estimate the failure load, as might be anticipated since the straight line is obtained from points obtained during the earlier (elastic) stages of the test and the magnitude of the error will increase with reduced length of the strut. There was considerable discrepancy between the experimental and graphically predicted results in struts with elastically restrained ends. This is to be expected, since a deflection curve represented solely by a series of sine functions cannot satisfy the end conditions relating to bending moment.

The authors wish to thank the authorities of the University of Nottingham and of Loughborough College of Technology for the facilities used and for permission to publish the results.

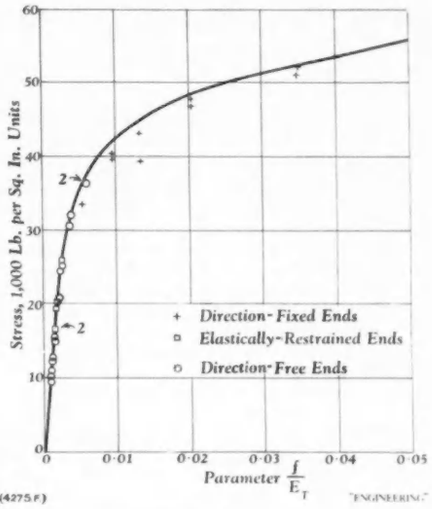


Fig. 6 Suggested method of plotting strut curve.

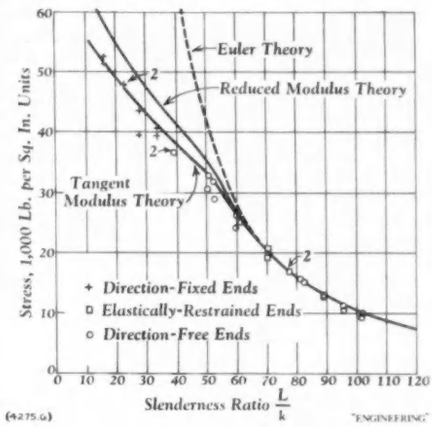


Fig. 7 Conventional plot for strut curve.

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THERMIONIC CONVERTERS

Ever since the first practical application of electricity, engineers have been concerned to improve the efficiency of converting heat energy to electrical energy and to simplify the machinery required for the conversion. While the 40 per cent. efficiency of the modern steam turbine/generator represents an important advance on the earliest types of generator, it demands complex equipment and is still far short of 100 per cent. However, a step towards the direct conversion of heat to electrical energy by means of a relatively simple apparatus has now been taken, though the efficiency of conversion is low and commercial application is still remote. Nevertheless, the ultimate advantage is sufficient to ensure further development.

The General Electric Research Laboratory at Schenectady, N.Y., has recently disclosed some details of its work on a new type of thermionic converter, designed for the direct conversion to electricity of heat available at very high temperatures, such as the exhaust of jet engines or high-temperature atomic power plants. The converter consists essentially of a hot electrode (above 2,500 deg. F.) that emits electrons for collection by another electrode which is cooled by an inert gas or other suitable coolant. A special gas environment is employed to facilitate the flow of electrons. Up to the present 3 watts per sq. cm. of hot surface is the highest power obtained with a conversion efficiency of about 8 per cent.

For the present, therefore, the thermionic converter, like the thermocouple and the thermogalvanic cell, can be regarded as useful only under very special circumstances, but it is considered that very substantial increases in conversion efficiency will be achieved.

Book Reviews

SOIL ATTACKS ON BURIED PIPES

Underground Corrosion. By MELVIN ROMANOFF. *National Bureau of Standards Circular* 579. *The Superintendent of Documents, U.S. Government Printing Office, Washington* 25, *D.C., U.S.A.* (3 dols.)

To the United States, with its thousands of miles of main trunk lines for petroleum and natural gas, underground corrosion has long been a serious domestic problem. It is not surprising, therefore, that the most extensive organised researches on the soil corrosion of metals, some of which date back for nearly half a century, have been undertaken by Americans.

The major part in these investigations has been played by the United States National Bureau of Standards. The scientists and technicians of the Bureau began their work in 1910 with a study of corrosion caused by stray electric currents and followed this about ten years later with an extensive series of field tests on the corrosive effects of soils alone on buried pipes, which they had found to be equally important. The latter research led to further experimental projects, so that tests of one kind or another continued over a span of more than 40 years. The extent of this work, in which the Bureau enjoyed the support of many American scientific societies, Government departments and industrial undertakings, is indicated by the fact that "between 1922, when the field burial programme started, and 1952, when the last of the specimens were removed from the test sites, more than 36,500 specimens, representing 333 varieties of materials, were exposed in 128 test sites throughout the United States."

The results and conclusions drawn from the researches have been published from time to time. Most of the early reports are out of print and it is somewhat difficult to follow the progress of the individual researches through such publications as are available. The National Bureau of Standards, therefore, felt it advisable to round off the investigation by publishing a considered survey of all the results obtained in the form of the present volume; although this is mainly concerned with their own investigations, its value has been materially increased by reference to the results of other important researches.

The author has marshalled his facts well and his exposition is good. After a short survey of the main investigations of underground corrosion, made to date in the United States and elsewhere, and a review of the corrosion theory involved, he discusses the results obtained in the various researches undertaken by the Bureau. Most of these relate to field tests on pipe materials, notably cast iron, steel, copper, lead, zinc, aluminium, and cement-asbestos, and on protective coatings, including zinc, tar, bitumen, and concrete.

Attention is also devoted to laboratory methods for determining the corrosiveness of soils and the value of protective coatings for use underground. Other sections of the book deal with the field inspection of pipelines, stray-current electrolysis, and cathodic protection. There is a good bibliography of 407 references and a series of valuable appendices, most of which are devoted to matters of experimental technique of considerable interest to other investigators.

Although the text is well written, readable, and clear, some of the line drawings, such as Fig. 80, on page 169, fall short of the highest standards; moreover, on the whole, the tables seem unnecessarily cumbersome for a final survey of this kind. The presentation of the results might have been simplified, without serious loss to the general reader, by classifying the many soils tested into a smaller number of typical groups and giving representative or average results for each group only; possibly some of the test materials could have been grouped in the same way. These are, however, but minor criticisms of what is undoubtedly the best and most complete treatise on soil corrosion that has yet appeared. It describes a fine piece of sustained scientific work, of which the United States National Bureau of Standards and their American colleagues can justly feel proud.

INDUSTRIAL REVOLUTIONARIES

The Smiths of Chesterfield: A History of the Griffin Foundry, Brampton, 1775-1833. By PHILIP ROBINSON. *Robinson and Sons, Limited,* and *Thomas Brayshaw, Limited, Chesterfield.* (15*s.*)

With the current enthusiasm for matters historical any addition to the industrial record is welcome, even if it be merely a glossy-papered commemorative brochure. But when an author who is an historian as well as an industrialist tackles the subject the result is a book which may well be taken as the archetype for future short histories of industrial concerns.

Mr. Robinson has spent a lifetime in industry, actually on the site of the firm whose history he is recording, and he was a managing director as long as 45 years ago. He has applied to his task not only a long and successful industrial and business experience but also a detailed local knowledge and a love of mankind. The result is a book which is a model of its kind. It recalls in detail the formation of the Smith Company, a firm which played an important part in the early stages of modern industry in the North Midlands. At one time employing 1,200 men, it was the largest iron producer in Derbyshire, in 1806 smelting more than 25 per cent. of the total output of the county. It had important connections with the early steam engine, producing cylinders and large haystack boilers for Francis Thompson and Boulton and Watt.

The histories of the individual shareholders and their families are traced back as far as 1627, and the personalities of individuals are illustrated by quotations from family letters. The industrial section of the book is lavishly illustrated by small sketches of plant, machinery and products, which have been made by artists of the author's company. The format of this section is unusual, and could well be copied in similar works. It consists of a series of notes, each with its sketch and each complete in itself, yet together forming a continuous narrative. Outstanding among the illustrations are one full-page bird's-eye perspective view of the Griffin Foundry as it was in 1788, and a smaller visualisation of the Adelphi Works at Duckmanton. These give an excellent impression of Eighteenth Century industry, with its jumble of smelting furnaces and fire-engines and haystack boilers, casting houses and coke crozling heaps, interconnected by tram-roads.

There are interesting details of journeys made by the partners, in search of business. These lead on to a description of the difficulties which arose during the 1830's, and of the struggles which were made to save the firm. Not the least valuable chapter is that in which the author analyses the causes of failure of the business, one of which was doubtless the long periods of time spent away from the works by the partners. This led to the following advice being given by a Robinson uncle who had been a contemporary of the Smiths who had failed: "My lad, give all your time to manufacturing and let paid men do the selling. Anyone can sell good stuff, but no man can sell bad stuff for long." There are extensive appendices containing in the main family letters, agreements, and correspondence between the Smiths and Boulton and Watt. The announcements of the sale of the works in 1836 give details of the contents of the buildings.

The book has been excellently printed, an important point in view of the large number of sketches which it contains. There are one or two minor misprints, and only one technical error. This is in reference to a 7 ton casting, which was made in 1831 for Dakeyn's hydraulic engine. As this engine is so little known, the footnote reference to a steam engine is excusable. Of value to all who are interested in engineering history or economic history far outside the region which it has covered so thoroughly, this book is a true labour of love.

TRADE PUBLICATIONS

Copies of any of the following trade publications are obtainable from the addresses given, though distribution is sometimes restricted.

Mining Equipment. WESTINGHOUSE BRAKE AND SIGNAL COMPANY LTD., 82 York-way, King's Cross, London, N.1. Four illustrated brochures, each self-contained, but punched for insertion in loose-leaf catalogue. The subjects covered are: general equipment for mine car decking and handling, marshalling and controlling; tilting platform decking; signalling and traffic control; car circuits at Ormonde Colliery.

Direct-Fired Furnace. THE INCANDESCENT HEAT CO. LTD., Cornwall-road, Smethwick, Birmingham. The Equiverse system, developed to provide "positively scale-free heating conditions" in a direct-fired furnace operating under fully automatic control of both temperature and atmosphere. Typical applications to pusher-type, continuous and rotary-hearth furnaces. Leaflet No. V54.

Light-Alloy Castings. J. STONE AND CO. (CHARLTON) LIMITED, Woolwich-road, London, S.E.7. The design, production, heat-treatment, mechanical and physical properties, and testing of aluminium-alloy and Elektron magnesium alloy castings. Two technical brochures. A leaflet on precision-cast wave guides employed in electronics is also included.

Colliery Equipment. PLOWRIGHT BROTHERS LTD., Chesterfield. Power-operated turntables for changing the direction of mine cars in a restricted space (No. 210). Plate feeder belts for handling coal, "dirt" and other bulk materials from skips, tipplers, hoppers and bunkers (No. 211). Illustrated folders.

Melting Practice for Aluminium Castings. ALAR LTD. (Association of Light Alloy Refiners), 3 Albemarle-street, London, W.1. Notes prepared for the foundryman to explain to him briefly and in simple terms the melting and preparation of aluminium alloys up to the casting stage. Revised version of booklet first published in 1951.

Heat Exchangers. HEAT EXCHANGERS LTD., 1 Wardour-street, London, W.1. High-pressure steam condensers, chemical exchangers, complete cooling equipment for electronic devices, oil and water coolers, heat exchangers for sewage plant, grass dryers, compressed air heaters. Illustrated catalogues.

Light-Alloy Lorry Body Sections. IMPERIAL CHEMICAL INDUSTRIES LTD., METALS DIVISION, Birmingham, 6. Kynal aluminium-alloy sections for motor-lorry bodies, floors, head boards, drop sides and tail boards. Illustrated booklet containing instructions and technical requirements.

Metal Cleaning. ROTO-FINISH, LTD., Mark-road, Hemel Hempstead. Details of the "Grisiron" range of alkaline metal cleaners. Thirteen types are listed, ranging from mild cleaners for use by hand to strong compositions used for paint removal by dipping. Illustrated leaflet.

Grinding Fluid. MOBIL OIL CO., LTD., Caxton House, Westminster, London, S.W.1. "Solvac 68" clear type synthetic grinding fluid, for ferrous and certain non-ferrous metals, ceramics, glass, quartz and optical lenses. Illustrated leaflet.

Steel Forgings and Fabrications. STERN AND BELL, LTD., Stour-street, Birmingham, 18. Details of steel forging, fabricating and stockholding service operated at the newly-opened Stour-street works. Illustrated brochure.

Motor Stock List. LAURENCE SCOTT AND ELECTROMOTORS LTD., Norwich. List of a.c. motors currently in stock.

NEW BOOKS

Technical Reports of the Electrical Research Association, *Thorncroft Manor, Dorking-road, Leatherhead, Surrey.*

"Debye Losses Due to Electrons Trapped at Vacancies," by J. A. Sussmann, L/T348 (9*s.*); "Surge-Voltage Distribution in Transformer Windings Due to Current Chopping," by E. L. White, S/T73 (12*s.*); "The Surge Electric Strength of Oil-impregnated Paper Wrappings," by G. W. Bowdler, S/T79 (12*s.* 6*d.*); "Developments in E.R.A. Impulse Testing Technique," by J. L. Miller and E. M. Dembinski, S/T80 (12*s.* 6*d.*); "Electronic Voltage Stabilizers for Laboratories, Computers and Control Systems" by J. Miedzinski and S. J. Zgorski, V/T130 (12*s.* 6*d.*); "A Network Analyser Test Problem" by P. G. Kendall, V/T131. (7*s.* 6*d.*)

The Conservation of Natural Resources. A series of lectures delivered at the Institution. *The Institution of Civil Engineers, Great George-street, Westminster, London, S.W.*1. (7*s.* 6*d. members*, and 17*s.* 6*d. public.*)

Seven lectures delivered during 1955 and 1956 at the Institution of Civil Engineers by authorities who view with concern the rapid expenditure of resources such as metals, land, and fresh water, brought about by increasing industrialisation, have now been published in brochure form. In a foreward, Sir Harold Hartley, G.C.V.O., F.R.S., states that conservation is particularly urgent in a crowded country like the United Kingdom, with our relatively small natural resources.

Typical Microstructures of Cast Metals. Edited by G. LAMBERT. *The Institute of British Foundrymen, St. John-street Chambers, Deansgate, Manchester* 3. (21*s. members*, 84*s. non-members.*)

Following the success, in pre-war years, of publications I and II entitled *Typical Microstructures of Cast Iron*, the Technical Council of the Institute of British Foundrymen decided to produce a new collection of microphotographs, including not only the well established foundry alloys but also covering the more recent developments in cast irons, and enlarging the scope by the inclusion of microstructures of steel and non-ferrous metal castings. The present book, which contains 294 half-tone illustrations of microphotographs, is the result. In most cases the actual chemical composition and mechanical properties obtained on the examples illustrated are given. In other cases, typical data are listed. This association of microstructure with composition and properties enhances the value of the book to students and producers and users of castings.

Plastics Materials Handbook. By ALAN B. GLANVILL. Machinery's Yellow Back Series No. 40. *The Machinery Publishing Company, Limited, National House*, 21 *West-street, Brighton*, 1. (4*s.* 6*d.*)

As is the case with similar volumes previously issued in this series, the present work is intended to be a concise reference book of the principal plastics materials, quoting their physical, mechanical and electrical properties and giving data on their forms, colours, applications, decoration and cementing. The plastics materials covered, both thermoplastic and thermosetting, are those in most common use, and throughout the work the trade names of the materials dealt with are listed.

Engineering Progress and the Oil Industry. Edited by GEORGE SELL. *The Institute of Petroleum*, 61 *New Cavendish-street, London, W.*1. (30*s.*)

Progress in every field of engineering has had a considerable effect upon the development of the petroleum industry, in that it has made possible the fabrication of the special plant now used in all spheres of the industry. It was with this consideration in mind that the Institute of Petroleum arranged their 1957 summer meeting on "The Influence of Engineering Progress on the Oil Industry." The subject was approached from the viewpoints of civil, mechanical, electrical, marine, and chemical engineering, respectively; and the metallurgical aspect was also considered. The result was a series of worthwhile papers and discussions which are reproduced in the present volume.

Standard X-Ray Diffraction Powder Patterns. By HOWARD E. SWANSON, NANCY T. GILFRICH and MARLENE I. COOK. National Bureau of Standards Circular 539, Vol. 7. *Superintendent of Documents, U.S. Government Printing Office, Washington* 25, *D.C.* (40 *cents.*)

The seventh volume in the series on standard X-ray diffraction powder patterns contains data for 53 inorganic substances. The information given is a compilation of diffraction patterns from all sources and is used for the identification of unknown crystalline materials by matching spacing and intensity measurements. The patterns have been made with a Geiger counter X-ray diffractometer, using samples of high purity. A cumulative index for all seven volumes in the series has been added.

Data Book for Civil Engineers. Volume II: Specifications and Costs. By ELWYN E. SEELYE. Third Edition. *John Wiley and Sons Incorporated*, 440 *Fourth-avenue, New York* 16, *N.Y.* (20 dols.); and *Chapman and Hall Limited*, 37 *Essex-street, London, W.C.*2. (160*s.*)

The specifications detailed in part one of the *Data Book* concern contract documents, site investigations, materials for structures, industrial buildings, airports, roads, railways, bridges, docks, dams drainage, sewers, sewage treatment, water supply, swimming pools, and athletic fields. In part two are set out, in meticulous detail and in dollar currency, building-trade wage rates and building and civil-engineering costs for all types of structures and undertakings. Part three consists of a glossary of civil engineering terms in all branches of that subject. The *Data Book* is in three volumes. Volume I deals with design and Volume III with field practice. Both are now in their second edition.

Sheet Metal Work (Part I) Geometry and Pattern Development. By R. G. BLACKBURN and J. CASSIDY. *Edward Arnold (Publishers) Limited*, 41 *Maddox-street, London, W.*1. (14*s.*)

The authors, both of whom are lecturers, state in their preface that they have endeavoured in this book to cover adequately the work required for the City and Guilds Intermediate Examination. They emphasise that it is essential to use the worked examples as a guide, while drawing them out step by step, and not just reading them through. After an introduction on plain and solid geometry come three sections, each with exercises, devoted to pattern development, first by the radial line method, then the parallel line method, and finally by triangulation. An appendix includes some examination questions.

Symposium on the Observation of Structures. Vol. I: Opening Speeches, General Report, Discussion. Vol. II: Papers. *Union of Testing and Research Laboratories for Materials and Structures, Laboratorio Nacional de Engenharia Civil, Av. do Brasil, Lisbon, Portugal.* (84*s.*)

The *Transactions* of the symposium on "The Observation of Structures," which was organised by the Union of Testing and Research Laboratories for Materials and Structures (RILEM) and took place at Lisbon in October, 1955, are contained in these two books. Subjects covered at the meeting included the descriptions and functions of instruments for the measurement of displacements, cracks, rotations, strains, stresses, temperatures and moisture content; properties of materials; and descriptions and interpretations of observations on dams, bridges and other structures. The first volume contains about 140 comments, some in English and some in French, by the 39 participants in the discussions on these subjects. The second volume contains the 54 papers presented. Here again, some are in the one language and some in the other, but, at the end of each paper, there is a brief summary of its contents in both languages. The books are well printed and well illustrated.

On the Shelf

By Frank H. Smith

The report of the President of the Massachusetts Institute of Technology gives one or two interesting figures and facts. Faculty salaries are "top priority" and the M.I.T. plans to raise at least 5 million dols. to be spent as a "wasting" (delightful expression) fund at the rate of 1 million dols. a year to raise faculty salaries. These have already been raised by an average of 15 per cent. since 1952. The Institute has doubled its enrolment since the war of 1939-1945 and now seeks to stabilise this enrolment to enable resources to catch up with growth. M.I.T. is determined to maintain its high quality of entrant, which is not surprising since each additional student requires the investment of an additional 50,000 dols. The Americans have the same difficulties as we have in respect of training teachers. The President says that the attractions offered by industry and government are too great by contrast with those offered by teaching institutions. About 20 per cent. of M.I.T.'s Ph.D.'s go into college teaching, M.I.T. is heading a movement to plan a new approach to the teaching of physics in secondary schools, part of which is the use of cinema films.

It would appear that M.I.T.'s schemes of financial aid to students are substantial and realistic. There is even a system of loans at 1 per cent. interest.

Coincidental with the M.I.T. announcement on the teaching of physics in schools comes a Press release from the American Institute of Physics which announces that the Institute's director is "embarking on a programme to help improve the quality and quantity of physics taught in high school and college." They, too, contemplate using television and cinema films.

In May, 1957, Messrs. W. H. Smith and Son Limited published the results of a survey they had made on a cross-section of school children and their reading habits. Of boys who answered 3,000 questionnaires in the age-range 11 to 18, in the answer to: "What would you like to be when you leave school," by far the highest percentage (9·60) wanted to be "in engineering." (The next best was medicine with 5·30 per cent.). This, by the way, was at public and grammar schools where some people would have us believe the accent is on classics. At secondary modern schools, where one expects technology to lead, engineering was still top with 16·30 per cent., and electrical technology came next with 5·50 per cent. I wonder what can have captured these lads' imagination? None of them seems to want to be a librarian or I could have offered some advice—one way or the other!

Our old friend L.L.U. (Lending Library Unit of the Department of Scientific and Industrial Research) is insisting, as from January 1, on the use, by borrowers of reports, of the Science Museum Library loan requisition forms. These forms are issued in pads of 50 to approved borrowers, the cost of the pads offsetting postage charges. The D.S.I.R. in their letter advising this stipulation say "it is hoped that this change of procedure will not cause users of report literature any difficulties." The pads of forms are obtainable from the Keeper of the Science Museum Library, Kensington, S.W.7, at 30*s.* per 50 forms, post free. Thus, it will cost three-fifths of a shilling to borrow a report.

The Computer Bulletin of the British Computer Society, 29 Bury-street, St. James's, London, S.W.1, seems to grow at a rate similar to that of other specialist publications. No. 2 of Volume 1, which was issued in August, numbered pages 21 to 44. No. 3, issued in October ran from page 45 to 132. The *Bulletin* is published in alternate months and the price varies, but application to the office of the Society will produce a price-list. Which reminds me that at least one of the funny stories regarding computers has come true. The *Daily Telegraph* of December 16 reported that a £73,500 machine at the U.S. Naval Supply Centre, Oakland, California, was fed a problem that was too much for it. "After a series of rumbles the machine caught fire and was destroyed."

Russian translation is now much in vogue and I have just received a copy of one which is entitled "The Synthesis of Polyorganosiloxano-aluminoxanes and Polyorganosiloxanotitanoxanes." That, of course, is the English version.

The bonding of metals is a technique that acquires a greater literature almost weekly and the Engineering Societies Library, 29 West 39th-street, New York 18, U.S.A., has produced a timely bibliography covering the years 1947 to 1957, on *Adhesive Bonding of Metals*. It is No. 12 in their series and contains 150 references. The price is 12 dols.

Design

PIECEMEAL YIELDING OF MILD STEEL

Theory Applicable to Problems Involving Stress Reversal

By K. Farnell, B.SC.(ENG.), A.M.I.MECH.E.

Observations of the strain markings on the polished surface of an overstrained mild-steel member indicate that the actual mode of yield propagation is considerably different from the perfectly plastic behaviour often assumed for analytical purposes. Hardness measurements for various partially-yielded tensile-test specimens suggest that, irrespective of the amount of yield for the specimen as a whole, the material contained in each slip band (Lüders line) is always in the *fully* yielded out condition, while the remaining material, between these bands, is still in the elastic state. So far as the individual elements of the material are concerned, it appears that there is no intermediate state between the two extreme conditions of complete elasticity and complete yield, and that, as straining proceeds, the number of fully-yielded elements is increased at the expense of the elastic elements.

Thus, during plastic straining, the horizontal line C E (Fig. 1) represents the mean behaviour of the mixture of elements within the test length, and the total (measured) elongation at any instant is the sum of the separate extensions of the elastic and plastic portions. Furthermore, once yielding has started at any single point, it is thereafter propagated to the remainder and greater bulk of the material at the lower yield stress f_L, and the upper yield stress f_U plays no further part.

For any *partially* yielded out member for which the total strain corresponds to that of point D (Fig. 1), the fraction (k) of the original gauge length l which has been transformed to the fully plastic condition can be readily determined by equating the total elongation $e\,l$ to the sum of the separate elongations $e_x(1-k)\,l$ and $e_p\,k\,l$ for the elastic and fully yielded portions, respectively, whence,

$$e = e_x + k\,(e_p - e_x) \quad . \quad (1)$$

or,

$$k = \frac{e - e_x}{e_p - e_x} = \frac{\text{A D}}{\text{A E}} \quad . \quad (1a)$$

The yield mechanism outlined above is particularly convenient when it is required to predict the recovery characteristics of a severely overstrained tension member during unloading, or even to predict the subsequent compression characteristic during reloading in the reverse direction. In these circumstances the elastic elements contract according to a linear stress-strain characteristic while the contraction of the fully-yielded elements proceeds according to a curve E E_2 (Fig. 1), here referred to as the basic reversal characteristic, and the shape of which can be determined from a separate test on a fully-yielded out specimen. By combining the elastic and basic reversal characteristics with regard to the relative proportions of the two types of element present, the behaviour of a partially-yielded member during load reversal is easily predicted. Thus, when a tensile specimen loaded up to point D undergoes a stress reversal f' (reckoned relative to the lower yield stress in tension), the corresponding strain reversal e' averaged over the gauge length is given by

$$e' = k\,e'_r + (1-k)\,e'_e$$

or,

$$e' = e'_e + k\,(e'_r - e'_e) \quad . \quad . \quad (2)$$

Equation (2) enables the curve DD_1D_2 to be constructed.

The method implies that the elastic elements remaining after the original tensile loading continue to behave elastically during the subsequent compression, i.e., k is assumed constant. This is confirmed by the author's tests which showed that the elastic portions do not undergo compressive yield during load reversal until the compressive stress attains the original lower yield value. The maximum extent of the compressive yielding which then occurs is directly proportional to the amount of elastic material present at this stage, hence the horizontal line D_2D_3 will be equal in length to the line DE. (The tension and compression characteristics O A E F and O A_3 E_3 F_3 for the original material are here assumed to be identical.)

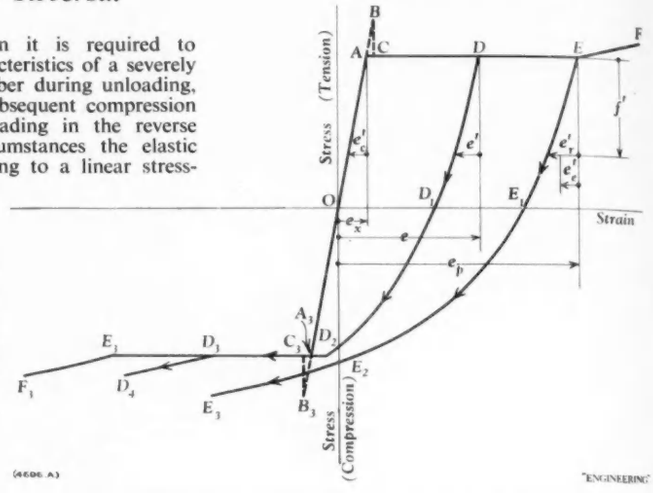


Fig. 1 Notation used in the derivation of reversed-loading characteristics for fully-yielded and partially-yielded tension specimens.

At point D_3 the gauge length will be fully yielded out, partly by the original tensile loading and partly by the subsequent compressive loading. As the yielding process is in both instances a shear phenomenon, the conditions within the specimen at this point are not likely to differ appreciably from those for a specimen which has been fully yielded out in, say, compression only. It follows then that further compression will produce strain-hardening as represented by D_3D_4, and that this curve can be expected to have the same shape as that of E_3F_3 for the original material.

The author's results for normalised material showed equal lower yield stress values in both tension and compression, but the strain value e_p at which strain-hardening commenced was consistently greater in tension than in compression. This feature was exhibited by two different batches of steel, and in each case the plastic-limit strain in compression was found to be only about two-thirds of the corresponding value in tension. In order to take this into account, let the ratio $e_p\,\frac{\text{(compression)}}{e_p\ \text{(tension)}}$ equal n, say. Referring again to Fig. 1, we must now arrange our diagram so that $A_3E_3 = n$. AE, and $D_2D_3 = n$. DE.

Fig. 2 illustrates the behaviour under compression of five test pieces, each previously overstrained in tension by a different amount so as to give various k values ranging from 0·138

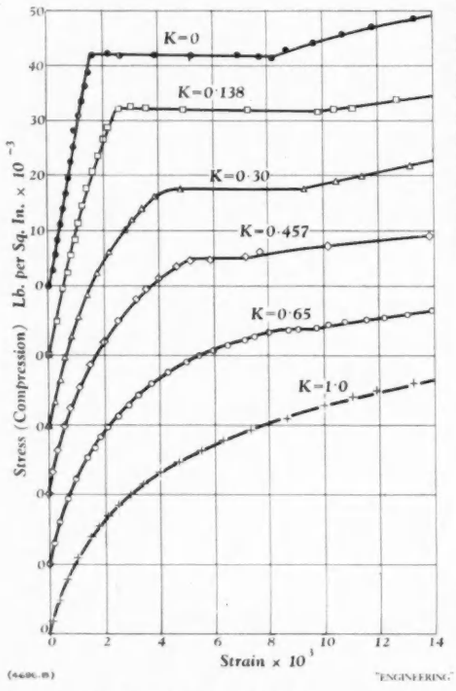


Fig. 2 Compression characteristics after various amounts of initial tensile overstrain.

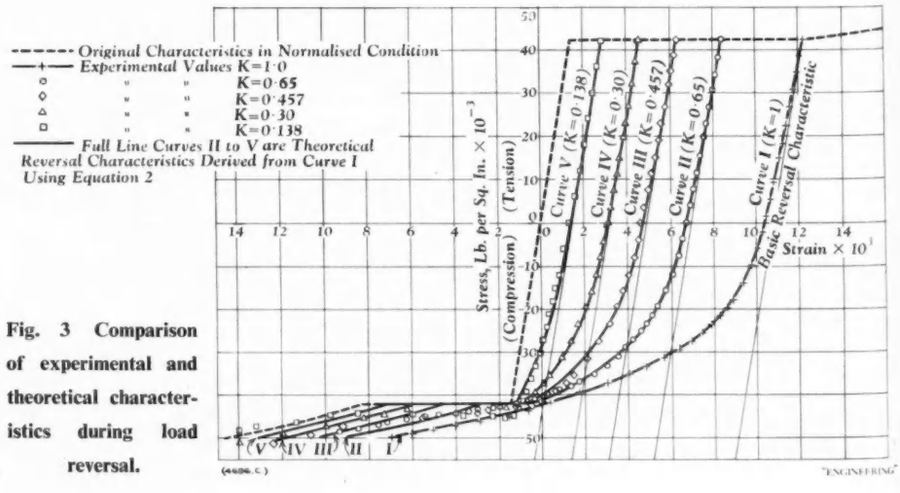


Fig. 3 Comparison of experimental and theoretical characteristics during load reversal.

to unity. These curves not only demonstrate the compression yield phenomenon, but also illustrate how the extent of this secondary yield is dependent upon the previous amount of plastic working in tension. The complete reversed-loading characteristics for these same specimens are given on a common diagram in Fig. 3 in order that they may be compared with the theoretical curves derived by the piecemeal theory. The agreement in the stress range between the tension and compression lower-yield values is so close that it is thought desirable to point out that the full line curves marked II to V are not intended to link the plotted experimental points, but are the theoretical characteristics deduced from the basic reversal characteristic (curve I), and included for purposes of comparison.

EFFECT OF RESTING

In each of the tests with which Fig. 3 is concerned, it was arranged that the compression test should follow on within a few hours of the previous overstrain test in tension. The effect of allowing an intermediate rest period of as much as two years has been investigated, and indicates that, in circumstances involving load reversal, the elastic recovery is far from being complete. The partial recovery which does occur may be allowed for by means of only a small modification to the original basic reversal characteristic.

Photocopies of the full paper, of which the above is a digest, are obtainable from the Publisher, ENGINEERING, 36 *Bedford-street, Strand, London, W.C.2. Price 6s. each, post free.*

CRITICAL SHAFT SPEED: EFFECT OF CASING FLEXIBILITY

"The Design and Development of Four Light-weight High-Speed Marine Gas Turbines for Electric Generator Drive" was the subject of a recent paper given before the Institution of Mechanical Engineers in London by Mr. A. W. Pope, chief gas-turbine engineer, W. H. Allen, Sons and Company, Limited. Mr. Pope dealt with four engines developed during the past eight years: two base-load machines designed for operating at full tropical ambient temperature—a 1,000 kW free-turbine alternator set with heat exchanger and a 500 kW two-shaft intercooled alternator set—both for the Royal Navy; and two emergency generator sets, one of 125 kW for the Royal Navy and one 350 kW set for the Merchant Navy. Among the development problems discussed were compressor and turbine aerodynamics—and the wide gap between present-day theory and practical results; the governing of a compound gas-turbine alternator; the effect of flexible bearing supports on critical speed—and this part of Mr. Pope's paper we reproduce, somewhat abridged, below; and the mechanical design of turbine casings to minimise losses due to clearance variations.

On the first run of a 350 kW gas-turbine, after the set had been running for about five minutes with the speed being gradually increased all the time, considerable vibration occurred at 12,000 r.p.m. and the set was shut down (full speed 15,000 r.p.m.). On stripping it was found that the centre labyrinth had rubbed badly. The clearances were increased and, at the same time, the vibration characteristics of the rotor mounted in the engine casing were checked. This showed that there was a natural frequency at 12,000 vibrations per minute, which was actually the only frequency at which a serious vibration could be detected. It was not possible to detect any natural frequency at the calculated whirling speed for the shaft, namely, 21,000 r.p.m. By rotating the rear bearing support through 60 deg. so that two of its arms straddled a flat weak section of the casing, it was found that the amplitude of the vibration was reduced to a quarter without the frequency altering.

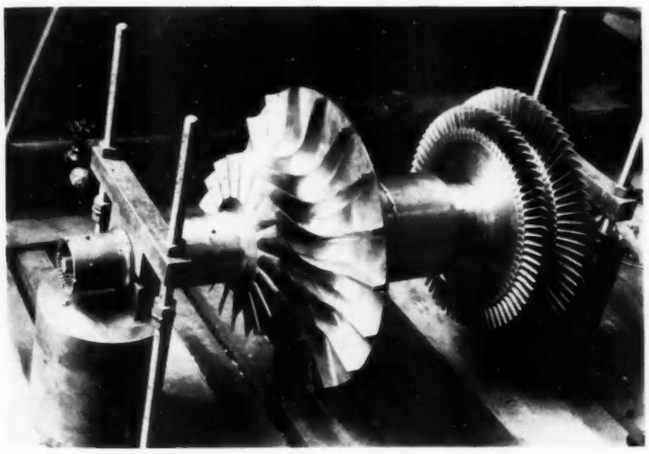


Fig. 1 Vibration test set-up on the compressor and turbine rotor assembly of a 350 kW gas-turbine.

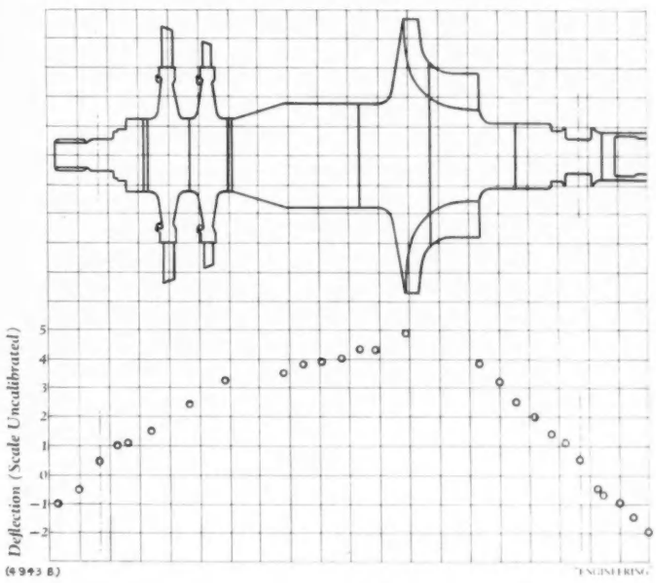
Although subsequent running was satisfactory, it was decided to investigate further the reason for the non-appearance of a natural frequency around the calculated whirling speed. First the rotor was mounted on V-blocks on a lining-out table of cast iron approximately 1 in. thick with fairly generous under-ribbing. The V-blocks were approximately 1 in. in axial width, and the support blocks were 10 in. high by 6 in. by 4 in., and of a hollow ribbed construction in cast iron. The rotor was excited at its mid-span position, the drive being from the table. The main mode of vibration occurred at 265 cycles per second and was a combined rotor-table vibration. The pattern of the rotor was of a see-saw kind, with the bearings moving in antiphase. It was not possible to excite the normal rotor fundamental with this system. It was then decided to replace the lining-out table by a more rigid foundation, namely, the test-house floor consisting of cast-iron bearers embedded in a concrete floor some 15 in. in depth. A fundamental mode for the rotor was immediately obtained, but of a very low frequency, and some detailed observation showed that the rotor journals appeared to be bouncing on the V-blocks and that the amplitude of vibration of the main support blocks was also quite considerable. The main supports were therefore bolted to the floor and the effect of reducing the energy input tried, the following frequencies being obtained: low energy input 210 cycles per second, high energy input 195 cycles per second.

As the V-blocks were fairly wide it was decided to fix more accurately the point of support. Strips of steel $\frac{1}{8}$ in. wide by 0·007 in. thick were therefore introduced under each journal at the nominal bearing centre-line. The following figures show that the insertion of the very thin strip reduced the value of the critical frequency by 7½ per cent.:—low energy input 182 cycles per second, high energy input 168 cycles per second.

Next the support system was clamped to the floor, using $\frac{3}{4}$ in. diameter bolts and two 1½ in. square bars across the top of the bearing levels, each carrying a 0·007 in. thick strip on their under-faces. The amplitude of the vibration of the support blocks was considerably reduced by this measure, and the nodes appeared on the shaft at approximately 2½ in. outboard of the bearing centre-line. A complete set of deflection readings was obtained and a frequency of 245 cycles per second recorded.

Lastly, the rectangular cast-iron blocks were replaced by sections of 8 in. diameter steel bar of approximately the same height, and the V-blocks were replaced by semi-circular blocks having a 1 in. axial land, Fig. 1. Each pair of mating surfaces throughout the support system was carefully lapped, and at a very low value of energy input a frequency of 313 cycles per second was recorded for the normal mode, that is, 18,750 r.p.m. A complete set of shaft deflection readings were taken, Fig. 2, and it will be noted that the nodes still lay slightly outboard of the bearing journal proper.

Fig. 2 Deflection of the rotor assembly.



It can be concluded therefore that the calculated critical speed of 21,000 r.p.m. is probably fairly close for an infinitely rigid type of bearing support. Important implications can be drawn from these tests concerning the value of the normal type of critical-speed calculations. It follows also that there are probably a number of high-speed engines which run, unknown to their designers, above their critical speed as a result of flexibility in their casing assembly. This is quite feasible because, with a well-balanced shaft, the movements produced by out-of-balance forces at the critical speed are often satisfactorily damped out by the bearing oil film, the engine casings and the internal damping in the shaft. Further, considering the very rigid nature of the

Continuing **Design**

supports in the experiment above, one would expect that engines having what appear to be extremely rigid bearing supports would also show an actual critical speed lower than the calculated value.

Rigid adherence to the normal method of estimating critical speeds can influence the layout and the number of bearings of an engine. There is, therefore, a big need for even an approximate quantitative theory to be evolved so that an estimate can be made in the design stage of the effect of the flexibility of various types of casing.

RESOLVING ANGLES

An electromagnetic angle transducer of high precision has been developed at Bell Telephone Laboratories, 463 West-street, New York 14. It is called the vernier resolver. The resolution is better than $\pm$ 3 seconds of arc. Bell Laboratories point out that this is about the same angle as that subtended by a baseball at a distance of 3 miles.

Such a resolver has applications for visual and automatic angle reading systems as required in the machine shop and in military applications. It has been used in an " angle encoder " that converts a shaft angle to a numerical representation acceptable to a digital computer. The standard deviation of the error of the complete encoder is less than ten seconds of arc.

The vernier resolver is a variable-coupling transformer of the reluctance type. In the present design, two output voltages are produced which vary in amplitude as the sine and cosine of 27 times the angle through which the rotor is turned. Thus, the equivalent of a standard resolver driven by a 27 : 1 gear train is obtained. Other ratios are possible. The unit is small and of simple construction. All windings are on the stator, leaving the rotor free of sliding contacts. Models of this resolver are being built by Clifton Precision Products Company, Clifton Heights, Pennsylvania.

H.M.S. VICTORIOUS UP-TO-DATE

Wartime Carrier Rebuilt

H.M.S. Victorious, commissioned on January 14, and commencing her preliminary sea trials early next month, has been modernised at Portsmouth Dockyard and is now the world's most up-to-date aircraft carrier. She is the first in the Royal Navy to be fitted with all the British-developed aids to Naval flying—the fully-angled flight deck, two steam catapults and mirror deck-landing aids, and is now capable of landing the latest and heaviest Fleet Air Arm aircraft. New high-speed lifts have been fitted with a combined area double that of those in the original ship.

The work carried out on the ship, which was built by Vickers-Armstrongs on the Tyne and completed in May, 1941, has been the largest task of its kind ever undertaken in a Royal dockyard or a commercial shipyard in the United Kingdom. At one stage some 2,300 men—mainly from the Constructive Department —were involved both on board the ship and in workshops ashore, while the figure has exceeded 2,000 throughout the past eighteen months. One of the many problems that had to be tackled during the modernisation, which was deliberately prolonged to enable all the latest equipment and developments to be incorporated, arose from the serious shortage of shipwrights at Portsmouth. Consequently, Devonport Dockyard carried out the prefabrication of No. 2 deck and the new island; the sections, each weighing about 30 tons, being transported to Portsmouth by ship.

In the course of the refit, the Victorious, which originally had a displacement of 22,600 tons, has been completely rebuilt above the hangar deck, and fundamental changes have been made to her structure. Before the reconstruction work could be undertaken, nearly 15,000 tons of plating, machinery and internal fittings had to be removed, while the weight of similar items added during the work carried out was some 19,000 tons. The underwater beam of the ship has been increased by 8 ft. and, as a result of the fitting of the angled deck, the overall beam is now nearly 150 ft. The depth from keel to the flight-deck level has also been increased by 4 ft.

H.M.S. Victorious, modernised and now fitted with a fully-angled flight deck, two steam catapults and mirror deck-landing aids.

To supply power for the catapults, larger boilers of much higher output have been installed and the whole capacity of the ship's auxiliary machinery increased, including more steam dynamos, evaporating plants and air-conditioning plants. New larger-capacity aviation fuel systems have been fitted, with filters designed to give a much higher degree of purity to the fuel. The main machinery can be remotely operated so that in an atomic attack it can be controlled from a centre supplied with filtered air. The electrical system has been renewed completely and the equipment used is in advance of any afloat at the present time.

The siting of the two-tier operations room, radar display room and associated compartments below the flight-deck level has enabled the size of the island to be kept to a minimum. Features of its outline are the large radar aerial—the first of its size to be mounted in a warship—and a conventional lattice mast at its after end and abaft the funnel.

The flight deck, just over 775 ft. long, is strong enough to take the heaviest of Fleet Air Arm aircraft, including the Blackburn N.A.39. Two parallel-track 145 ft. catapults are fitted forward with aircraft positioners and jet-blast deflectors. The steam for these catapults is provided from the wing boiler rooms on No. 6 deck forward. The arresting gear comprises four wires with an average span of 80 ft. A single emergency barrier made of nylon is carried. Deck-landing mirror sights are fitted port and starboard, the angled deck necessitating the port sight being mounted well outboard on its own large sponson. Two hydro-pneumatic operated centreline lifts will adequately handle the required working load.

The fully angled deck is the ship's most striking feature. An angle of 8¾ deg. has been achieved by extending the flight deck outwards for 41 ft. on the port side for a length of 120 ft. It overhangs the ship's side by some 35½ ft. The extension is supported by an enormous sponson bracketed into the ship's structure. The overhang represents a compromise between the most efficient flight deck layout and the need to obviate risk of damage in a seaway.

The upper gallery deck of the Victorious is unique in a British carrier. It is continuous for the length and full width of the ship. Situated immediately below the flight deck and above the hangar, it is, in effect, a development of the deep beam system of the flight deck, the beams being deep enough to provide the necessary headroom for accommodation and office spaces. Fore and aft access on both sides of the ship is provided at this level, the space gained through this extension being used primarily for accommodation and dining halls. It is air-conditioned and fully lagged because of the exposed deck above.

The main hangar is divided into two sections by a fire curtain of asbestos cloth. The usual spraying arrangements are fitted, while the lift opening to the main hangar can be sealed off by hydraulically-operated hangar doors. The lift opening to the hangar extension, which is equipped to serve as an electronics servicing bay, can be cut off by a fire curtain.

The ship is powered by three sets of steam turbines and can be steamed from the machinery control room by hydraulic remote controls. The main generating capacity has been increased from 2,400 to 4,200 kW, including additional Diesel generators, and most of this has now been absorbed by ever-growing demands for electric power. The ship's original d.c. ring main system has been retained. Other generators and conversion machines have been provided to meet the varied and various requirements for radio, radar, weapon control and communications.

The radar fitted in the Victorious has been described as the best ship-borne air defence radar in the world. It combines early warning and high discrimination of an aircraft's position in plan and height simultaneously. A complex semi-automatic electronic system collects and displays the information provided by this radar. A further new high-discrimination radar with a computer is also fitted to " talk down " aircraft safely on to the deck in all weathers.

The A.B.C.D. (atomic, bacteriological and chemical defence) on the ship has been arranged on a much bigger scale than for previous ships. This has been made possible by the adoption of a grouped ventilation system in which fewer but larger fans are used. In a contaminated area fans to the control centre can be " crash " stopped from the breaker rooms, the ventilation trunks subsequently being closed by quick-acting gas flaps. Air filtration units enable a small quantity of fresh air to be supplied to the control centre during the closed-down period.

Production

THE LATEST IN PRODUCTION PRACTICE

When aircraft were first made, any metal-working necessary was done by the normal engineering techniques of the time, and this still applies, of course, to many of the parts required for modern aircraft. But as the aircraft industry grew, its particular production problems brought about the need for many special machines and techniques, and to-day engineers outside the industry can find in its activities a two-fold interest. Continuing developments in aircraft production will provide both a field and a challenge to those who develop new techniques and production equipment and, of course, new materials of construction. Conversely, there may well be much developed for the aircraft industry which will have applications elsewhere. At the sixth annual conference on Problems of Aircraft Production, organised by the Southampton Section of the Institution of Production Engineers, and held at Southampton recently, both present and future trends were discussed.

The rapid advances being made in technology were stressed by Mr. Boyd K. Bucey, vice-president—manufacturing, Boeing Airplane Company, Seattle, Washington, U.S.A., who presented the Lord Sempill Paper, " Manufacturing in the Aeronautic Age." Increasing complexity in design and consequent long development times dictate that improvements shall be made in large increments, perhaps cutting out an intermediate design, and this work has to be done in a financial atmosphere which has changed in both Great Britain and the United States. The golden era of exciting advances with seemingly unending Government funds available is over and cost of production is now of vital importance. The American aircraft industry is fully alive to the changed conditions in which it has to live, and is in the process of adjusting itself accordingly. To this end it is not only reviewing its organisational methods, but is also actively developing new production techniques.

In the cutting of metals, especially sheets, strips and plates, which is fundamental to airframe construction, the necessary accuracy can generally be achieved by orthodox equipment, though certain methods such as friction sawing are becoming more common; and a new patented method of making blanking dies for sheet metal is also prominent. Known in America as the " cookie cutter," the blanking die is constructed of rule stock, and, in spite of its apparent flimsiness, is capable of blanking thousands of parts from steel up to $\frac{1}{4}$ in. thick. The cost of such a die is only about one-tenth that of the conventional type.

Parallel with developments in cutting is a decided movement towards the use of techniques which reduce the amount of machining required. Precision forgings are particularly successful examples of the so-called " chipless " technique, especially as recently produced " draftless " forgings, which are without the normal small taper on the die, have been developed to reduce the amount of machining required still further. Such desirable results are not achieved without great expense, however, as it is only on very large and powerful presses that large close-tolerance forgings can be made. There are only two such presses in the United States at present, one of 50,000 tons and one of 35,000 tons capacity. Nothing of comparable size exists in this country. Much development work is still needed in high-precision forging, and also in the two other processes used for " chipless " production—precision casting and impact extrusion. Both have a high potential value, but relatively little progress has been made in their development.

In spite of the urgent need for less machining, and the efforts being made in this direction, it is true to say that the amount of machining is increasing. This had led to the development of better machining techniques, and the introduction of new methods of metal removal, some of which are not, in the accepted sense, machining at all. Chemical milling or etching, now used extensively on aircraft components, is really only a modification of etching as used commercially for many years in such work as name-plate production, to mention only one example. The technique has proved so successful that to-day it has an almost unlimited future. It has particular advantages for shallow sculpturing, tapering, and close control of thickness tolerance, and, by suitable manipulation of the masking, can be used to etch to different depths on a single component, as well as to leave chosen parts untouched.

Forming techniques have been developed to cope with more complex three-dimensional shapes, many of the processes involving stretching the material beyond its elastic limit. Stretch-forming is familiar throughout the aircraft industry, and this technique is now being increased in range by heavier equipment, as is sheet-metal working with rubber dies. Newer processes include explosive forming, a variation of impact forming; this involves the use of an explosive charge in dies of special form to force metal to the shape required. Shot peening is also being used for metal forming; by varying the intensity with which the shot strikes the metal surface, and the speed of movement of the nozzles, simple shapes can be formed quickly and cheaply.

All these new techniques, and the development and mechanisation of older ones, provide a challenge to engineering designers which is being met in various ways, many of them as ingenious as the new techniques themselves. Plastic tooling, new metallic die materials, and new fastening methods for joining airframe parts have taken their place with new methods of handling components, such as freeze chucking, which enables honeycomb material to be held for machining by freezing it to a refrigerated chuck with water; any form of mechanical clamping would cause distortion, and a magnetic chuck would be useless on non-magnetic material.

BRITISH PRACTICE

A paper entitled " Manufacturing Practice—A Review of British Aircraft Industry," by Mr. S. G. Burnard, M.I.Prod.E., A.F.R.Ae.S., of Vickers-Armstrongs (Aircraft), Limited, surveyed British practice thoroughly, and showed that in many ways the aircraft industries of the two countries under review run on parallel lines, a point which was also made by Mr. Bucey.

Dealing first with machining, Mr. Burnard referred to routing, a method which, incidentally, was taken from wood-working, and adapted to the particular needs of aircraft production. Routing is now used very widely, and it is only necessary to refer here to some actual and projected developments. Overhead template routers have simplified operation by making it possible to remove the work without first lifting the template out of the way, and servo-operation has reduced the manual effort needed.

Programmed control of machine tools is, as would be expected, proving of great interest to aircraft production engineers, particularly where relatively small numbers of parts have to be made to precision limits, as is so often the case with airframe construction. Orthodox tooling would be costly, and the same objection would apply to manual production by highly-skilled workers. Control of machine tools which are basically of normal design, by means of a programme set into punched tape or cards, can be very much cheaper than the alternative means of production when working on limited quantities, and there are now several types of control equipment on the market, which can operate with sufficient accuracy to be used on jig borers if required. In addition, several aircraft manufacturers have built or are building complete machines with numerical control to meet their special requirements.

PIPE BENDING

The amount of piping used in aircraft construction has increased enormously, and some mechanical means of pipe bending is essential. Several bending machines can be purchased from manufacturers in this country, and others have been developed by the aircraft industry itself. A particularly interesting example of internally-developed equipment is the extrusion pipe bender. In this machine a straight length of pipe is mounted in a collet on a carriage which can be power-traversed along the bed of the machine. The pipe is pushed through a fixed die and then through one which is movable, and if the second die is displaced in relation to the first as the pipe is traversed, the pipe will emerge in the shape of a bend. The greater the displacement of the die the sharper will be the bend, and if the pipe is rotated the bend will take place in a different plane. Die control and collet rotation are achieved by means of cams on two camshafts, and the cams can be adjusted to produce the series of bends required. It is intended to dispense with the cams and so save the time required for machine setting, by means of electronic punched tape control.

As in the United States, chemical methods of metal removal are being used by British aircraft manufacturers increasingly, and an interesting development is a process for reclaiming worn files. A worn file is immersed in a bath of 56 per cent. sulphuric acid, and an electric current is passed between the bath and the file, the voltage being 8 and the load, for a 10 in. file, 100 amps. Electrolytic action causes preferential erosion of the flanks of the file teeth, and so produces a new cutting edge. Files can be reclaimed up to seven times, at negligible cost.

A study of the papers presented at the Conference makes it clear that the aircraft industries of Great Britain and the United States are both fully aware of the need for continued improvement of existing methods and the development of new techniques. The activities of the industry will be worth following both by those engineers who are seeking new ideas for production, and by those who have developed new machines, techinques or materials.

WASHING WITHOUT WATER

To save production time otherwise lost in going to and from washrooms, and also to provide hand washing facilities on construction sites and in similar places where a permanent installation is not practicable, portable equipment which does not require the use of water has been developed by Deb Chemical Proprietaries, Limited, Belper, Derbyshire.

The equipment consists of a cabinet type unit, carrying a visible level dispenser for " Swarfega " waterless skin cleanser, and two paper towel dispensers. The pillar of the unit houses a canvas sack into which soiled paper towels can be dropped through slots. There is storage space below the sack for paper towels and cleanser. Swarfega waterless cleanser reduces dirt to an emulsion, which is then wiped away on a paper towel. The wash equipment can thus be completely self-contained, no installation is needed and it can be moved from place to place.

Engineering at Home

AUTOMATIC OIL BURNING

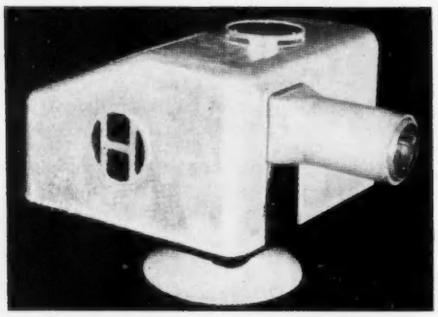


Fig. 1 (left) The type A oil burner uses light oil and is designed for automatic operation in domestic heating installations.

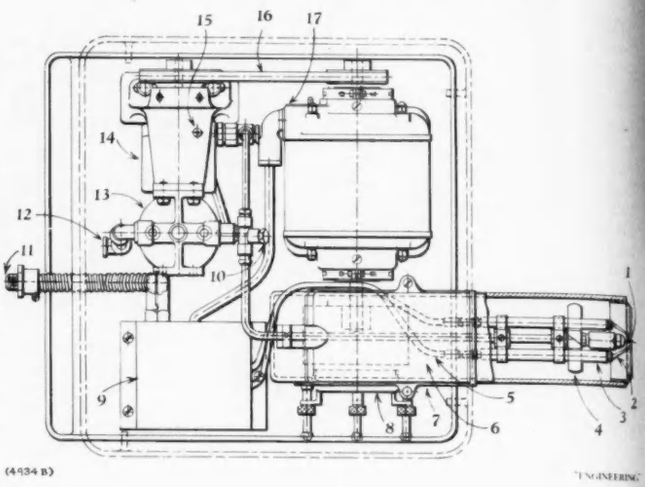


Fig. 2 (right) The plan of the burner shows the location of the fan and oil pump in relation to the electric motor.

Key: 1 atomiser, 2 spark electrodes, 3 porcelain insulators, 4 air turbulator, 5 h.t. ignition leads, 6 removable cover plate on draught tube, 7 fan housing, 8 adjustable air control, 9 ignition transformer, 10 ¼ in. B.S.P.T. connection for pressure gauge, 11 ¾ in. E.T. conduit connection, 12 ¼ in. B.S.P.T. oil connection, 13 oil filter, 14 oil pump with built-in pressure regulator, 15 bleed screw, 16 V-belt drive, 17 motor.

A new showroom for the display of heating equipment has been opened by Hope's Heating and Engineering Limited, Smethwick, Birmingham. The company occupy the ground floor of 16 Berners-street, London, W.1, together with the basement, mezzanine and first floor. A feature of the ground-floor showroom is the suspended ceiling that combines radiant heat with noise reduction, by means of coiled hot-water pipes behind acoustic panels. Both are suspended independently from the existing ceiling, and heat radiates through the perforated panels. Excessive noise is absorbed both by the panels and by the thermal acoustic pad fitted above the pipes. The pad serves to reduce heat loss to the floor above.

On show at Berners-street is the range of fully automatic pressure-jet oil burners made by Hope's. As will be seen from Fig. 1, the burner has been given a dust cover—made from cast aluminium finished bright—that makes it look more acceptable in the home. It is designed for setting on a brick or concrete base, but an adjustable floor mount is available if required.

The makers say that the burner needs very little attention. Thermostats regulate it and ensure rapid response to demands for more heat. An existing boiler can be converted to oil burning fairly quickly. Once an oil tank is installed, the burner can be fitted in 24 hours. It burns light fuel oil (35-40 seconds viscosity Redwood No. 1 at 100 deg. F.).

The burner complies in all respects with BS.799/1953 relating to petroleum base oils. It is complete with control panel, adjustable boiler thermostat or steam pressure control, flame failure device, electric motor, direct-driven multivane fan and housing, adjustable air control, oil filter, oil pump, pressure-regulating and cut-off valve, ignition transformer, electrode assembly, and combustion head. The control panel is separate from the main burner and mounts on a wall; it comprises two main operating parts—a motor-contactor controlling the oil-burner motor, and a heat-motor switch that, in conjunction with a thermostat in the boiler flue, ensures the required sequence of safety features.

A ⅓ h.p. drip-proof resilient-mounted split-phase motor drives the fan. It operates from 200-240 volt single-phase alternating current supplies and runs at 1,425 r.p.m. On the motor shaft is mounted a multiblade centrifugal fan. The impeller is made of mild steel and is enclosed in a cast-iron casing. The fan inlet has an air-control damper for adjusting the air supply to the burners.

For the oil feed, an annular piston or integral gear oil pump is fitted. A combined pressure-regulating and cut-off valve, embodying an adjustable spring-loaded piston, gives the necessary control. The pressure ranges between 80 and 150 lb. per sq. in. Constructed of steel throughout, the valves maintain the correct oil pressure at the nozzle.

A brass atomiser delivers the oil into the combustion chamber as a finely divided spray. The high conductivity of the brass ensures that heat is carried away from the atomiser and so reduces the tendency to form carbon there. The orifice head is made of chrome-nickel steel. Atomiser nozzles are supplied with three different angles of spread—45, 60, and 80 deg. The spread angle has to be chosen to suit the shape of the combustion chamber. Nozzles are provided in numerous sizes related to the output of the burner, and are selected to avoid direct flame impingement on the walls and floor of the combustion chamber.

An electric spark provides ignition. After the initial start the spark shuts off and does not operate again until called for during another starting sequence. A single-phase transformer steps up the mains voltage to 10,000 volts—the working voltage of the ignition system. Two insulated high-tension cables couple the transformer to the adjustable ignition electrodes. These are in the burner air tube and firmly mounted to ensure alignment and rigidity. The whole ignition and combustion head forms a single unit that is removable for inspection and cleaning without altering the set adjustment of the electrode points. The internal air turbulator unit is mounted on this assembly.

WINDOW-CRACKING RUST

Sometimes, for no apparent reason, the glass in the kitchen window cracks. You come down one morning and there it is. Cracked. Or else it may be the bathroom window that suffers. Or, more rarely, some other window in the house. One unfortunate estate had this trouble in a big way: an average of 4 panes per house per year needed replacement. Clearly the phenomenon could get out of hand if allowed to go on uninvestigated.

The Building Research Station, Garston, Hertfordshire, studied the problem. They found that when the glass is fixed in steel window frames, the cracking is always associated with rusting of the steel. The formation of rust, particularly at the back of the putty, puts the glass in a state of strain. This in itself may be enough to cause the glass to crack. Otherwise, movement of the metal frame due to temperature changes may crack the glass by imposing further strain. Thus cracking may occur at night, when the frame cools down after a hot day.

The results of the investigation are given in *Building Research Digest* 104. Kitchen and bathroom windows are affected more than others because there is a greater chance of moisture condensing on their internal face. The moisture runs down and, where the putty is not full, lodges in the position where it can do most damage.

A substantial coating of zinc gives adequate protection against rust. Galvanised steel window frames will not give rise to cracking of the glass. Treatment of existing frames is often complicated by the frame rusting where it is in contact with the concrete. Where rusting is serious it is better to fit a new frame. In less severe cases the old putty should be replaced, and at the same time the metal should be given adequate protection with paint.

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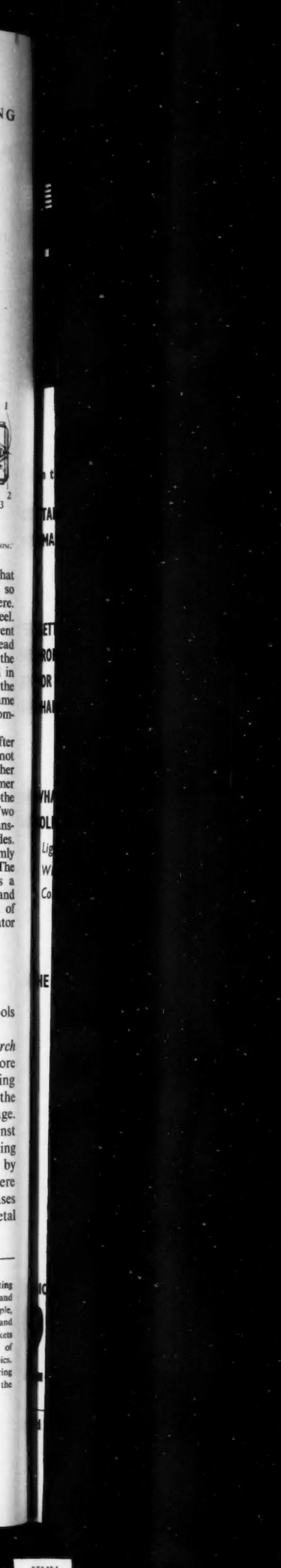
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